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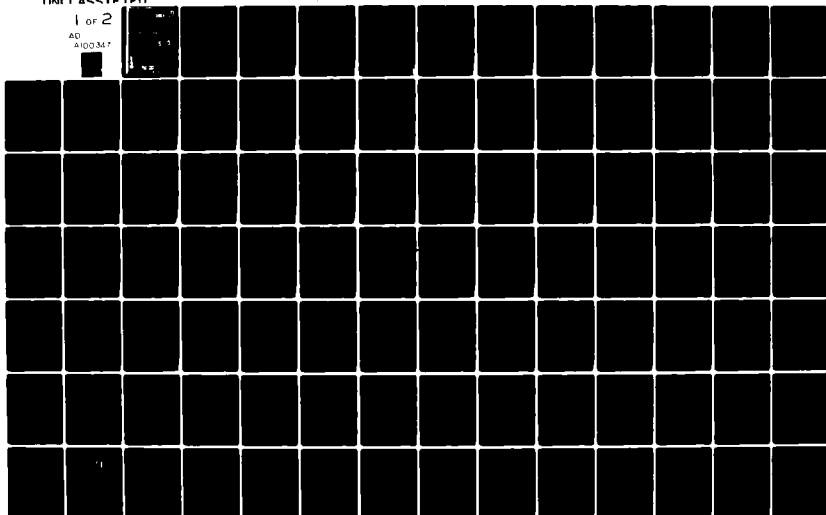
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RECOVERY FROM FATIGUE

Annual Summary Report

Frederick J. Evans and Martin T. Orne

March 1975

(For the period 1 July 1973 to 30 April 1975)

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ABSTRACT

With the aim of evaluating the potential of napping for facilitating unimpaired continuous performance over long periods, four interrelated studies were carried out: (1) 430 young adults were administered a specially developed questionnaire to elicit nighttime and daytime sleep patterns. Parametric findings are reported. (2) Based on questionnaire responses, supplemented by an extensive interview, individuals typical of three response patterns were selected: (a) replacement nappers--those who use daytime sleep to make up for lost nighttime sleep, (b) appetitive nappers--those who derive psychological benefit from daytime sleep regardless of fatigue, and (c) confirmed non-nappers--those who avoid napping because they "feel worse afterwards than before." A subsample of 33 individuals typical of these three groups took a one-hour afternoon nap where physiological and psychological parameters were recorded. (3) These subjects were subsequently requested to keep a 14-day sleep diary which permitted a more detailed analysis of the relationship between daytime and nighttime sleep. Several interesting and reliable differences between these groups in the physiological nature of naps and the consequences of napping were identified. (4) A collaborative study was carried out with the University of Louisville Performance Research Laboratory to evaluate the effectiveness of two short-term cognitive measures used in our past research to assess the restorative effects of napping on performance.

Descriptors: Fatigue, Napping, Sleep, Performance, Sleep Efficiency, Psychophysiology, EEG, Oral Temperature, Alpha Density

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FOREWORD

In conducting the research described in this report the investigators adhered to the Institutional Guide to DHEW Policy on Protection of Human Subjects as outlined by the National Institute of Mental Health. The Research Review Committee of the Pennsylvania Hospital evaluates the protocols of studies being conducted, the type of subjects, method of recruitment, screening process, as well as the risks, voluntary participation and the manner in which informed consent is obtained. The procedures were most recently reviewed and approved on November 27, 1974.

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1. INTRODUCTION

Approximately one-third of our life is spent in sleep. Each of us is familiar with the feeling of satisfaction that follows a good night's sleep as opposed to the enervating experience of increasing fatigue, the progressive difficulty of sustaining effort, and the acute discomfort that eventually follows from a lack of sleep. Despite the obvious importance sleep has for man and animal, the known deleterious effects of sleep deprivation, and the apparently obvious relationship between sleep and recovery from fatigue, the precise physiological consequences brought about by sleep remain obscure. Extensive research over the past 20 years, stimulated by the observation that sleep is neither a passive nor a unitary phenomenon, has produced considerable information about the process without, however, bringing us much closer to answering the question of why sleep is needed.

Though the need for sleep is ubiquitous, the manner in which sleep is obtained and the rituals surrounding it vary widely. Similarly, the amount of sleep required for well being is greater among the very young, stabilizes during the middle years, and declines somewhat in old age. Though general facts are well established, it is the individual differences in sleep requirements that are of greatest interest. Many individuals are able to get along without any difficulty on less than 6 hours of sleep a night, while others barely manage with 10. Since these differences appear unrelated to body weight, size or obvious metabolic

processes, it seems likely that, whatever necessary physiological changes are wrought by sleep, individuals differ in the efficiency with which they are capable of bringing about these changes.

The discovery of specific sleep stages and the demonstration that individuals selectively deprived of one stage are unable to replace their deficit with another stage of sleep also suggests that specific components of sleep are necessary for effective recovery from fatigue. Clearly, however, sleep involves more than simply going through physiological stages. Thus, it has been shown repeatedly that patients suffering from insomnia may in fact have normal amounts of sleep--even with an appropriate distribution of stages. Nonetheless, they complain that they have not slept, or they insist that they do not get enough sleep and yearn for a good night's rest. These individuals know what they mean by a good night's sleep; they only occasionally have this experience and bemoan the difficulty of getting it more frequently. Clearly, simply going through the physiological stages of sleep does not necessarily bring about the rejuvenation which each of us hopes to experience as we begin each day anew.

Considering the little we know about the basic reasons why sleep is required and the biological changes it is supposed to bring about, it is hardly surprising that we lack reliable information about basic daily sleep requirements, the kinds of sleep that are necessary, how the deleterious effects of long-term sleep deprivation can be minimized, and the like. These and many related questions will lend themselves to ready

resolution only when the biology of sleep is elucidated. In the meanwhile, however, a number of questions of both practical and theoretical significance about the nature of sleep and its function in recovering from fatigue can nonetheless be addressed. As we have pointed out previously, all of the work exploring the effects of sleep deprivation has focused primarily on the decrement in performance over time. Our interest, on the other hand, has been in exploring the restorative functions of sleep, in particular carefully controlled short periods of sleep.

While most individuals prefer periods of sleep extended over several hours, preferably during the nighttime, there is considerable anecdotal evidence about the effective use of short periods of sleep to bring about rapid recovery from fatigue, thereby allowing the individual to carry out difficult and demanding tasks for sustained periods without sleep of the usual kind. Thomas Edison, for example, thought that his invention of the light bulb would help eliminate one of mankind's most extreme forms of overindulgence--nighttime sleep--presumably by doing away with nighttime darkness! He was known to have worked for extended periods of time, interrupted only by brief naps. Winston Churchill is another outstanding example of an individual capable of sustained performance over long periods of time, relying almost exclusively on napping as a means of recovery from fatigue.

Napping behavior has received remarkably little attention on the part of sleep researchers. Nonetheless it appears to us as ideally suited to address the question of how individuals recover from fatigue.

There are wide individual differences in the tendency to nap and the extent to which individuals are willing and able to utilize this form of brief sleep in dealing with fatigue. Furthermore, napping behavior shows the greatest promise for making possible sustained performance without deleterious effects over long periods of time.

More so than nighttime sleep, napping lends itself quite readily to investigation, and it is possible to study physiological changes associated with napping as well as the changes in performance and subjective experience following napping. In many ways we believe that the study of subjective changes is a crucial and often overlooked approach to the investigation of human performance. While under conditions of extreme deprivation it becomes relatively easy to establish performance decrements, under most test conditions even individuals who are seriously fatigued, and whose continuous work performance might well be impaired, would nonetheless score within their normal range if they are motivated to carry out a relatively brief test procedure. On the other hand, these same individuals are quite capable of accurately reporting feelings of fatigue and difficulty in maintaining attention long before these experiential changes reflect themselves as deficits on objective criteria. From our point of view, then, the study of subjective reports is in part an important extension of performance measures; in part, however, it is also an important measure in its own right. Thus subjective reports are highly sensitive to changes in factors such as depression, confusion, anger, fear, and the like, which reflect aspects

of what is generally termed morale. Such changes, even if quite extreme, are hardly ever reflected in the kind of performance measures employed in the laboratory though they have profound effects on behavior outside experimental settings.

The systematic study of the effects of short periods of daytime sleep on recovery from fatigue makes it possible to examine concurrently physiological changes, performance changes, and changes in more subtle subjective terms. It becomes possible to address questions such as the nature of "a good nap" as opposed to a nap which has not been satisfying to the individual, to establish what psychophysiological mechanisms may be responsible for the good nap, and how it helps reduce fatigue. One important projected line of inquiry is to determine how adequately individuals who use the nap as a means of recovery from fatigue are able to function continuously without any extended periods of sleep. Further, it is our intention to identify those individuals who are capable of utilizing naps efficiently in order to ascertain what characterizes their naps as a prelude to the task of training other individuals to nap effectively.

The present report will briefly review the limited literature on napping and then focus upon the major studies carried out during the past year. These studies are most appropriately divided into four inter-related but separate major foci:

1. The further clarification of napping patterns in the normal population based upon a detailed study of self-reported questionnaires.

This extension of past research has been crucial to help identify specific patterns of napping behavior.

2. The report of a laboratory study involving 33 individuals selected as "ideal types" of appetitive, replacement, and non-nappers. In this special sample, physiological changes, subjective changes, and reaction time changes on awakening are explored.

3. A preliminary study based on extended sleep diaries of the selected subsample of individuals referred to above to help determine the function of the nap in the daily life of this population.

4. In view of the importance of appropriate performance tasks and the considerable investment of effort by our laboratory to design appropriate measures of fatigue useful for the present program of research, the two tasks we have developed were compared with the best available measure of fatigue--continuous work performance.

The Study of Napping

The major thrust of our ongoing work has been concerned with the parameters of napping. For many people a brief nap seems to have restorative value that far exceeds the length of time involved. While for some people, napping is an unpleasant experience and an undesirable waste of time, for others it is a necessary and sometimes involuntary outlet in the face of overwhelming fatigue. Still others would appear to integrate a nap into their daily life style as an important contribution to their psychological well-being. At the height of the

mental hygiene movement a number of popular and scientific articles advocated the nap as an integral part of mental hygiene and of equal importance to eating habits and cleanliness (Stegman, 1932; editorial, Military Surgeon, 1952). However, even as early as 1900, some anecdotal data suggested that the benefits of napping were in part a function of the time of the day the nap occurred. Moyer (1903) reported impressionistic evidence suggesting that afternoon and evening naps were more beneficial than morning naps.

Contemporary literature about napping (which will be reviewed only cursorily here) has been concerned with three general issues: developmental aspects of napping, sleep stages during napping, and effects of naps on nighttime sleep parameters.

Developmental Aspects of Napping. A series of studies has been concerned with developmental changes in sleep patterns. Some of these have included napping time as part of the total 24-hour sleep time. It is, of course, well known that napping is common in young children, declines through adulthood, but may increase in incidence as old age begins to occur (Chant & Blatz, 1928; Kleitman & Engelmann, 1953; O'Connor, 1964; Reynolds & Mallay, 1933; Scott, 1931; Tune, 1969a; 1969b). Daytime napping in young children mostly disappears by about five years, broadly corresponding with the beginning of school. Perhaps not coincidentally this is also the time that sleep disturbances first begin to occur in some young children. Although the incidence of

napping increases with old age, the total 24-hour sleep time of the elderly does not seem to differ from that of adults in the 20-30 year old range (Lewis, 1969). Both sleep about 7.6 hours per 24 hours; about 5 percent of this is taken up by napping in the elderly. Tunc (1969a) reports less than 1 percent of sleep time is taken in the form of naps by unselected young adults.

Some of our earlier work suggested that naps containing delta sleep may be non-beneficial, and that habitual nappers may have learned to avoid delta sleep during their naps. There are no studies reporting whether delta sleep occurs in the naps of the elderly, but the reported increased frequency of napping and the simultaneous decreased frequency of delta sleep during the night in the elderly (Feinberg, Koresko and Heller, 1967) suggest that delta activity may be an important variable in the evaluation of sleep quality.

EEG Sleep Stages During Naps. Another series of napping studies has been concerned with the EEG stages of sleep during naps of various lengths. Studies by Maron, Rechtschaffen and Welpert (1964), Webb, Agnew and Sternthal (1966), Webb and Agnew (1967), Karacan, Finley, Williams and Hirsch (1970a), Berger, Walker, Scott, Magnuson and Pollack (1971), and Lawrence (1971), using various samples and different lengths of naps at different times of the morning, afternoon and evening, have in general shown the following: (a) REM sleep predominates in morning naps and in fact, a morning nap seems

to be a continuation of night sleep; (b) delta sleep does not typically occur in morning naps, but is progressively more likely to occur during the late afternoon and evening hours; (c) in habitual nappers sleep onset for a nap is significantly faster than their sleep onset at night, or nighttime onset of non-nappers; (d) like nighttime sleep, REM rarely occurs at the onset of a nap. There is some evidence that REM onset may occur a little sooner during naps than during nighttime sleep, particularly if the nap occurs in the morning. In general, depending upon the time of the day, EEG sleep patterns during a nap look like corresponding night sleep records. Morning naps appear to be a continuation of the previous night's sleep. However, they are relatively infrequent, accounting for only about 4 percent of naps in over 400 subjects (Lawrence, 1971). Late evening naps may be equivalent to the beginning of regular nighttime sleep.

In our own earlier napping studies most of these findings were confirmed. However, five important but tentative results require further investigation in our current work, as they have not been reported in the existing literature.

1. Naps that terminate by suddenly waking the subject from delta sleep tend to lead to feelings of dissatisfaction more than naps terminating in other sleep stages.

2. Some nappers seem to have the ability to "squeeze" sleep. If the subject knows that he has a limited time to nap, he is likely to cycle through stage 1 and 2 sleep more rapidly than if a corresponding

length of record is scored for a subject who does not know how long he will be allowed to nap.

3. Depth of sleep, the subject's satisfaction with the nap, and recovery from subjective tiredness differed for nappers and non-nappers. These variables were also related differently to the total sleep time and the amount of stage 1 sleep.

4. Evidence from subjects' estimates of nap length suggested that nappers may not consider stage 1 as a part of satisfying sleep, whereas non-nappers include stage 1 in their definition of sleep.

5. Some evidence suggested that the nap among some habitual nappers improved their psychological well-being and helped to reduce anxiety. This finding, and related anecdotal evidence, led to our growing conviction of an important distinction between what we have labeled the appetitive and replacement napper.

Effect of Nap on Night Sleep Stages. The third series of studies concerned with napping have asked questions about the effects of daytime napping and nighttime sleeping. These studies have been limited in scope. For example, Karacan, Williams, Finley and Hirsch (1970b) found that although morning naps did not affect night sleep, if afternoon naps contained stage 4 or delta sleep, then evening sleep tended not to contain as much delta sleep as usual. They suggested that total amount of delta required for 24 hours may be a constant; a finding that has interesting implications for our own findings, as well

as the relationship between the amount of delta in naps and nighttime sleep of the elderly.

In general, these studies have shown relatively few consequences of napping on the subsequent night's sleep. There is some tendency for sleep onset to be delayed following a long nap (Karacan et al, 1970b) but an earlier study based on subjective reports by Kleitman, Mullin, Cooperman and Titelbaum (1937) suggested that this may be a function of the length of nap. They reported a long nap interfered with sleep onset that night, but a short nap actually led to faster sleep onset that night. In a sleep diary study of young children, Chant and Blatz (1928) found a positive correlation between daytime nap length and nighttime sleep length in young infants aged one to three, but by the age of five, a negative correlation was found suggesting that by about the fifth year napping reduced the need for nighttime sleep.

Our own previous studies have not addressed this question. We are currently exploring the effects of the laboratory nap on the subjects' reported sleep parameters--not only on the night after the nap, but also for the night before the nap. It may be just as important to ask what characteristics of a night's sleep lead to a decision to nap the following day as it is to ask what effect the nap has on the subsequent night's sleep. The sleep diary study reported below will take up this issue in some detail, both in terms of the effects of the laboratory nap on the preceding and subsequent night's sleep, and also in terms of those days in which naps did or did not occur while the sleep diary was being completed.

Incidence of Napping. There have been a limited number of interesting reports on cross-cultural attitudes towards napping, particularly in relation to the siesta. Lawrence and Sharley (1972) report surprisingly that the frequency of napping in the college age population in Guatemala (52 per cent) is considerably lower than it is in college students in the United States (76 percent) in spite of the traditional siesta time in Guatemala. In contrast, Taub (1972) found a high incidence of napping associated with the Mexican siesta: 78 percent of Mexican students napped four or more times a week (compared to a similar frequency in only 26 percent of Guatemalan students). Cultural attitudes towards napping vary a great deal. Thus, while the Hindu believes that a daytime nap will satisfy some of his nutritional requirements, the Tibetan fears a daytime nap because he believes it will lead to fever. It seems likely that many of these cultural differences are related to geographical and economic conditions (see also Aubert and White, 1959; Kleitman and Kleitman, 1953; Murray, 1965).

Several paper-and-pencil questionnaire studies have addressed themselves to the question of typical sleep length, nap length and frequency of occurrence of naps. Studies by Kleitman et al (1967), Cohen (1944), O'Connor (1964), Feldman (1970), Tunc (1969a), Goursey and Lerner (1974) and Lawrence (1971) would seem to support the following generalizations, at least among college student populations. Young adults typically go to bed at about 12:45 and awaken at about 8:15, obtaining about 7.5 hours of sleep. While mean values are surprisingly

consistent across studies, several authors comment on the considerable day-to-day variability in sleeping habits. Lawrence (1971) has shown that nighttime sleep parameters are quite different on weekdays or on weekends, and in terms of whether the students work or not. Most of these length-of-sleep figures do not take into account time spent napping.

The incidence of napping is more difficult to evaluate because of different ways in which different studies have asked the question. However, most studies report including a "never" or "very rarely" category of napping and a fairly consistent figure of about 40 percent typically respond as non-nappers. Napping length varies from a few minutes to over three hours, but most studies report a broad modal nap length of slightly longer than one hour. In the most careful survey conducted so far, Lawrence (1971) found naps of 2 hours or more in only 5 percent of the 460 subjects who reported napping. Lawrence also observed that when napping time is added to night sleep time, the total length of sleep per 24 hours is about 1/2 hour longer for habitual nappers (those who nap more than once a week) compared to non-nappers.

Recuperative Effects of Sleep

The third area we have been investigating has been concerned with the beneficial effects of sleep and the measurement of the recovery from fatigue. Most of the studies in the literature that have been concerned with the effects of sleep on subsequent waking performance have

employed a sleep deprivation model to study the consequences of sleep loss in terms of performance and, occasionally, psychological variables. They have involved either total or selective sleep deprivation of varying amounts. Our own research has adopted a different approach. We have sought to evaluate improvement in performance as a function of sleep, and our basic model has been to compare subjective and objective measures preceding sleep or napping with performance after the completion of the sleep or nap period. In other words, we have been concerned with the advantages that accrue after sleeping, and in particular, after having a nap.

Much of our previous work has been concerned with what turned out to be a lengthy and difficult problem of developing appropriate tasks to measure the recovery functions of sleep. This work has been reported earlier. The development of these tasks led to a collaborative study with the Performance Research Laboratory, University of Louisville, concerned with performance and recovery from fatigue in subjects on a 4-hour-work, 4-hour-sleep continuous performance regime.

In summary, our aim has been to study the functions of sleep in order to improve the efficiency with which the psychological and physiological benefits of sleep can be obtained. In the past year we have carried out a major investigation on the nature of napping, emphasizing differences between those who derive considerable satisfaction from regular napping and those who avoid napping apparently because of its undesirable consequences for them. As well as a large sample

questionnaire survey on napping ($N = 430$), we studied nappers and non-nappers in a standard sleep laboratory daytime napping study. In addition we engaged in a collaborative performance study on the recuperative effects of shortened sleep cycles on a continuous work regime. Each of these areas of research is described below.

2. THE PARAMETERS OF NAPPING

The ongoing research program has provided insights into potential differences in the habitual sleep patterns of people who nap and those who do not. However, very little is known about the subjective aspects of the napping experience. In our exploratory work, it became clear that people have quite divergent views about why they do not nap very often, citing many reasons ranging from lack of time and difficulty in falling asleep, to adverse psychological or physical consequences, and so on. Similarly, some people nap to make up for previous (or anticipated) loss of sleep time. Others seem to nap more as a life style than for reasons of fatigue. Yet others attempt to use napping as a means of relieving the tensions of everyday living. For some people the nap seems to have some psychodynamic significance rather than merely serving as a means of recovering from fatigue. Even more striking are the extreme individual differences in attitudes towards daytime sleep and behavior related to napping.

The Napping Questionnaire

An exploratory questionnaire was devised to serve two quite different functions. First, we wished to find out more about napping, and about the choice not to nap. While there were a number of areas in which the same kind of information was required from all participating subjects, for subjects who did not nap some of these questions were not

meaningful. Thus, it is awkward to be asking a non-napper about the time he takes his regular naps and his reasons for napping. Consequently, one section of the questionnaire was developed to be completed by those who considered themselves to be frequent nappers; another for those who labeled themselves as non-nappers.

The second purpose of the questionnaire was to select subjects who represented reasonably pure types of napping patterns. This would include confirmed non-nappers as well as two types of nappers: (a) those who nap primarily for sleep need or replacement reasons--making up for sleep lost, or in anticipation of lost sleep; (b) those whose reasons for napping were more psychological or appetitive, and in whom fatigue does not appear to be the important consideration for most of their naps. While it is possible that many people nap for a combination of both appetitive and replacement reasons, our aim was to identify relatively pure groups available for the proposed laboratory daytime sleep study reported below.

The questionnaire contained a broad spectrum of questions with several different answer-formats required to aid convenient quantification.¹ The napping questionnaire (see appendix) is divided into three sections.

Part I: The first section asks general questions about subjective sleep satisfaction and the overall quality of sleep, as well as specific questions to provide estimates of quantitative sleep parameters. Some questions were expected to relate to the ease of voluntarily controlling

sleep onset under a variety of circumstances, which is the broad dimension under which our previous work has indicated that napping may be subsumed.

The final question in this section was "Do you take catnaps during the day?" The subject was required to respond on a 5-point scale (5 = always; 1 = never). Depending on the answer to this question, subjects proceeded to either the green Part 2, or the blue Part 3 sealed sections of the booklets. If a subject's answer to the napping question was either "rarely" or "never," indicating that he rarely or never took catnaps, he was requested to complete the sealed green section of the questionnaire. If, however, he answered "always," "usually," or "sometimes," indicating that he catnapped on at least some occasions, he was requested to break the seal on the blue section and complete only that section.

Part II: This section was answered by subjects who responded that they "rarely" or "never" took catnaps. The subjects answered questions concerned with why they did not nap, as well as providing information about the time during the day when they were either most tired or most alert, under what conditions they might consider taking a nap, and any differences they felt existed between napping and sleeping. Some of these questions required answers based on the 24-hour clock, some on a rating scale on which 5 indicated "definitely applies," and 1 indicated "irrelevant" or "does not apply."

Part III: This section was filled out only by people who responded that they do nap at least sometimes. Information was obtained about their reasons for napping, time spent napping, and the consequences of napping. Questions were included to distinguish between the two different kinds of nappers, described below, that we were interested in studying.

Subjects--Original Selection Sample

The specially designed napping questionnaire was administered to a large introductory psychology class.² During a break in the 2-hour class, 512 volunteers filled out a receipt for \$2, which they found located under their seat. Any student who chose to participate in the "sleep survey" by completing the questionnaire on his own time was given, in exchange for this signed receipt, a stamped envelope addressed to the laboratory which contained \$2, the napping questionnaire, and the standard informed consent form used by the laboratory. The subjects completed the napping questionnaires at their leisure and mailed them to the laboratory. Between the class date, 11/8/73, and an arbitrary cut-off date of the start of the next semester, 1/21/74, 430 questionnaires were received. Three weeks after the last questionnaire was received, a letter reminder was sent to the 82 outstanding subjects, and 30 second reminders were sent about 5 weeks later. Valid questionnaires were returned by 474 (93 percent) of the 512 students who attended the class, but only the initial 430 (representing 84 percent of the distributed

questionnaires) were included in the data analysis reported in this section.

Of the 430 subjects, 261 (60.7 percent) completed the blue section for nappers, while the remaining 169 (39.3 percent) filled out the green non-napper section. Detailed comparisons between these non-nappers and nappers will be reported below.

Criteria for Laboratory Napping Study

This questionnaire was also used to select the subjects who would meet specific criteria, thereby qualifying to be invited to nap at the laboratory. Based on the results from earlier pilot samples, specific criteria were set up in order to identify those subjects who would qualify for inclusion in one of the three different groups in the study. These criteria were defined exclusively in terms of specified responses to the questionnaire. Not all qualified subjects could actually be invited to the laboratory, either because of their expressed unwillingness or unavailability when they filled out the informed consent form or because a mutually convenient schedule could not be worked out.

Consistent Nappers. The consistent napper had to indicate (blue section, question 1) that he napped with a frequency of at least once a week (or four times a month). In addition, in response to the question (blue section, question 18) "Do you find that naps are generally very satisfying?" the subject was required to answer "Definitely Yes" or

"Possibly Yes." Nappers who did not meet these criteria were considered to be inconsistent nappers for the purpose of the study. Based on these criteria, 62 nappers were classified as inconsistent nappers, leaving 199 consistent nappers (76 percent of all nappers). Of the 261 nappers, 3 percent indicated they "always" napped, 21 percent indicated they "usually" napped while 76 percent marked "sometimes."

Consistent nappers were then further divided into two subgroups, appetitive (N = 43) and replacement (N = 156) nappers. Subjects were considered to be appetitive nappers if their answer to (blue section, question 27) "Do you nap even when you do not feel very tired?" was either "Definitely Yes," or "Possibly Yes." However, a subject was considered as a replacement napper if he answered "Possibly No" or "Definitely No" to this question (#27).

In summary, a subject qualified as a potential napper for the laboratory study if he napped more than once a week and found that naps were generally satisfying. He was further designated as an appetitive napper if his naps did not necessarily occur in response to feeling tired, or as a replacement napper if he indicated he napped mostly when he felt tired.

Consistent Non-Nappers. Of 169 non-nappers, 135 answered they "rarely" napped, and only 32 (19 percent) answered that they "never" napped. It became clear that there were several kinds of people who labeled themselves as non-nappers. For example, one group of subjects

clearly indicated that they once did nap regularly, but no longer do so. The previous period of napping was sometimes associated with specific factors like illness, pregnancy, or childhood, but in many instances there were periods in the subject's life when he napped frequently for reasons other than the transient special conditions mentioned. (Some of the characteristics of non-nappers who once napped will be discussed below.) It was felt that these subjects were not necessarily representative of the typical confirmed non-napper unless the occasional napping occurred only in the context of a natural situation like pregnancy or illness. We were concerned only with locating subjects who did not nap because of a strong emotional conviction that they did not find napping beneficial or satisfying.

Confirmed non-nappers were thus required to answer "No" to the question (#3, green section) "Was there a period of time when you did take naps at least sometimes?" Two other questions (green section, question 1, parts K and L) were also critical in defining these habitual non-nappers: "Napping produces unpleasant physical aftereffects."; "Napping produces unpleasant mental aftereffects." These were rated by the subjects on 5-point scale questions. Both of these questions had to be rated 3, 4, or 5, indicating that the reason applied to the subject at least some of the time. Alternatively, at least one of these questions had to receive a rating of 4 or 5.

In summary, the confirmed non-nappers who were potentially available to be selected for the laboratory study reported they hardly

ever nap, at least in part because for them napping produces unpleasant physical and mental aftereffects. Only 13 of the 169 non-napper subjects met these stringent criteria.

Results

Sleep Parameters of Nappers and Non-Nappers

Table 1 presents self-reported parametric data for all of the nappers and non-nappers concerning evening and morning sleep and arousal time. Questions regarding when the subject felt sleepy, went to bed, fell asleep, awoke, got out of bed, length of time slept, were all asked both in reference to "last night" and "usually." Although correlations between "last night" and "usually" responses were typically around .50, it could not be expected that any single night of sleep in a college population would relate to overall sleep patterns. Indeed, response variability was probably the most noticeable aspect of the data reported in Table 1. The data in Table 1 reflects response to "usual" patterns.

In general, typical parameters of going to sleep and waking up were not very different for nappers and non-nappers. Both groups reported typically sleeping 7 hours and 26 minutes: all subjects averaged 7 hours and 22 minutes "last night." The standard deviation of "last night" (1 hour and 51 minutes) was significantly greater ($F = 3.16$; $p < .001$) than for the typical night (1 hour and 25 minutes). This might suggest that the typical night's parameters include sleep patterns that contain irregular hours (such as weekends), but the nappers may have

TABLE 1

Comparison of Self-Reported Sleep Parameters
in Non-Nappers and Two Kinds of Nappers

	All Ss		Qualified Ss **		
	Non-Napper	Napper	Non-Napper	Napper Appet. Replace	
Reported Time	N=169	N=261	N=13	N=43	N=156
Time very sleepy	23:49*	23:13*	00:10	22:35	23:19
Time go to bed	00:43	00:46	01:06	00:20	00:49
Time fall asleep	01:04	01:02	01:26	00:39	01:01
Time woke up	08:23	08:28	08:52	08:33	08:25
Time out of bed	08:32	08:43	09:06	08:59	08:39
Hours slept last night	7:28	7:19	7:47	7:33	7:11
Hours sleep regularly	7:28	7:25	7:38	7:31	7:27
Hours sleep like	8:26	8:34	8:36	8:33	8:35
Hours sleep need	7:50	7:58	7:53	8:05	7:56
Minutes to fall asleep	:20	:21	:20	:23	:18

Note. --All data reported in hours and minutes (24-hour clock-time).

* $p < .05$ All other t-test comparisons insignificant.

**All F-ratios comparing 3 groups insignificant.

already adjusted this typical time to take into account any nap they may sometimes take. The only variable differentiating the two groups was the question about "What time do you usually feel very sleepy at night?" Nappers report doing so 26 minutes earlier than non-nappers ($t = 2.64$; $p < .01$),³ but they both report typically going to bed within 2 minutes of each other (at about 12:46 a.m.).

The answers to most of these questions were typically more variable for the napper subgroup. It is not known if the variability is a function of taking daytime naps on some days, but it is consistent with the nappers' greater control of the sleep process.

There are no significant correlations between the question about napping frequency and these typical sleep parameters.

It is of some interest that subjects obtain about 7 hours and 26 minutes of sleep, would like to have over 8 hours and 49 minutes, but feel they need 7 hours and 55 minutes of sleep (each of these values differs significantly from each other). Globus (1969) similarly found that 51 subjects slept 7.1 hours, but reported they needed 8.1 hours; however, these were specially selected subjects who obtained excessively long sleep (exceeding 10 hours) at least once a week. He attributed the greater "sleep need" as a symptom of excessive sleeping, but our results show that this is a typical feeling among college students.

Sleep Satisfaction in Nappers and Non-Nappers

Table 2 summarizes the responses on the first part of the napping questionnaire of nappers and non-nappers to a number of characteristics

TABLE 2

Comparison of Subjective Night Sleep Characteristics
in Non-Nappers and Two Kinds of Nappers

Variable	Score	All <u>Ss</u>			Qualified <u>Ss</u>		
		Non- Napper N=169	Napper N=261	p <	Non- Napper N=13	Appet. Napper N=43	Replace. Napper N=156
Sleep as deeply as you like	Yes=1	.71	.80	.05	.69	.74	.82
Wake up slow, lethargic		.67	.77	.05	.69	.72	.75
Sleep well last night		.83	.80	--	.77	.72	.83
Sleep well usually		.82	.88	.10	.85	.84	.91
Could sleep now		.50	.79	.0001	.46 ^a	.86	.78
Wake up during night	Always = 5	2.57	2.45	--	2.69	2.56	2.44
Fall asleep easily		3.36	3.60	.01	3.54	3.67	3.65
Sometimes sleep too long		2.41	2.16	--	2.85	2.67	2.40 ^b
Sometimes sleep too short		3.29	3.51	.001	3.38	3.47	3.53
Sleepwalk		1.14	1.14	--	1.23 ^c	1.35 ^d	1.08 ^e
Sleeptalk		1.93	2.05	--	2.15	2.19	1.95
Find sleep satisfying		4.20	4.28	--	4.31	4.12	4.39
Difficulty falling asleep		2.64	2.56	--	2.62	2.79	2.44 ^f
Are you deep sleeper		3.47	3.61	--	3.38	3.60	3.63
Take catnaps*		1.83	3.28	.0001	1.54 ^g	3.51 ^h	3.26 ⁱ

Note.--A superscript indicates that the subgroup differs from at least one of the other subgroups. No superscript indicates that the subgroups do not differ.

*One of the selection criterion variables: non-napper group must differ from the napping Ss.

related to evening sleep. In spite of the lack of differences in the amount of sleep typically obtained at night, there were predictable differences between nappers and non-nappers in their subjective attitudes towards and satisfaction with sleep. Compared to non-nappers, nappers report that they sleep as deeply as they like to (80 percent versus 71 percent respond "Yes," $p < .05$) and typically sleep well (77 percent versus 67 percent, $p < .05$) although they may more often wake up feeling slow and lethargic ($p < .05$). Non-nappers are more likely to feel they did not get enough sleep ($p < .001$), but perhaps this merely implies that the napper has the mechanism to make up for lost time when he has such a feeling. Nappers more frequently report that they could go to sleep "right now" (79 percent versus 50 percent, $p < .0001$) and typically fall asleep more easily during the night ($p < .01$).

Thus, nappers seem to be more satisfied with how they sleep, and maintain a general readiness to be able to fall asleep "now," presumably a capacity they have at their avail whenever they need it. These results are further confirmed in Table 3, which clearly indicates that nappers rate themselves (on a 5-point scale) as significantly more likely and able to nap in a wide variety of circumstances including on long car, plane, or train trips, while studying, reading aloud, or while attending lectures, theater or movies, or watching T.V., following a good meal, and at times of stress. In some of the open-ended questions, napping in these circumstances was reported to be a voluntary process as frequently as an involuntary one.

TABLE 3

The Ease of Falling Asleep in Specific Situations
in Non-Nappers and Two Groups of Nappers

Do you fall asleep:	All <u>Ss</u>			Qualified <u>Ss</u> **			
	Non- Napper N=169	Napper N=261	p <	Non- Napper N=13	Appet. Napper N=43	Replace Napper N=156	p <
On long car trips	2.75	3.13	.0001	2.33 ^a	3.02	3.21	.01
While reading a book	2.25	2.72	.0001	2.15	3.00 ^b	2.69	.01-
While studying	2.06	2.56	.0001	2.00 ^c	2.79	2.56	.01-
During a play	1.35	1.54	.01	1.38	1.77 ^d	1.46	.05-
On plane or train trips	2.37	2.68	.01	1.35 ^e	2.44 ^f	2.81 ^g	.01
While watching movie	1.73	1.99	.002	1.46	1.98	1.99	.10
During lectures and speeches	1.82	2.25	.0001	1.62 ^h	2.30	2.20	.02
At times of stress	1.61	1.81	.05	1.38 ^j	2.21 ^k	1.73 ^l	.01
While watching TV	2.28	2.46	.05	2.15	2.49	2.47	.10
After a particularly good meal	2.11	2.56	.0001	2.00	2.70	2.56	.01

Note. --Answers rated on 5-point scale: 5 = Always, 1 = Never.

* F-ratio (df 2, 210)

** Groups sharing common superscript do not differ significantly, i.e., a subgroup without a superscript does not differ statistically from the other non-superscripted groups.

These clear-cut results provide strong confirmation of the hypothesis that one of the major characteristics of the napper is his ability to choose when he wants to fall asleep. In Table 1, a tendency ($p < .10$) was noted for the napper (particularly the appetitive napper) to delay going to bed longer after he first felt very sleepy than the non-napper, perhaps because of his confidence that he could either fall asleep quickly or would be able to make up for any lost sleep at a subsequent time.

A general index of falling asleep in a variety of circumstances was derived by summing the number of times the subject checked the extreme category "5" or "always," on these ten questions. The mean degree of voluntary control of sleep for nappers was significantly greater than for non-nappers ($p < .0001$).

Sleep Parameters in Consistent Appetitive and Replacement Nappers

Differences between the consistent appetitive ($N = 43$) and replacement ($N = 156$) nappers (i.e., those who nap at least once a week and enjoy it) in relation to nighttime sleep are summarized in Tables 1, 2, and 3. They are also compared where relevant with the consistent non-nappers ($N = 13$).

The two groups of nappers did not basically differ from the pattern described above for the complete sample of 430 subjects. Again, as can be seen in Table 1, evening sleep patterns seem comparable in all subjects. Consistent nappers and non-nappers seem to go to bed at the

same time, sleep about the same length of time, and get up at about the same time. These subjective estimates presumably exclude time spent napping. Of some interest however, is the discrepancy in the "last night" and "typically" answers of replacement nappers in terms of length of time slept. They reported sleeping only 7 hours and 11 minutes last night compared to a typical night's sleep of 7 hours and 27 minutes ($t = 2.08$; $p < .05$). The appetitive nappers and the non-nappers did not differ in their two reports ($t = .37$ and $.17$, respectively). This suggests that the sleep of replacement nappers is more variable than that of other groups, and their sleep habits may not be regular, thereby creating the need for periodic replacement sleeping. Indeed, all answers of the replacement subgroup were more variable than the other two, further supporting the replacement nap concept.

In spite of the restricted range imposed by the selection criterion of at least a nap per week, appetitive nappers more frequently engage in napping than replacement nappers. This is apparent both in their answers to the 5-point catnap selection criterion question on part 1 of the questionnaire ($t = 2.16$; $p < .05$) as well as the reported frequency of napping on part 3 of the questionnaire. Thus, the qualified appetitive nappers take 16.9 naps per month compared to only 12.8 naps for the qualified replacement nappers ($t = 2.13$; $p < .05$).

The fact that these subjects nap regularly indicates that they may potentially receive more total sleep during the 24-hour day than the non-nappers. This question will require further analysis in a subsequent

section where daily sleep diary data for 14 days is available for 33 nappers and non-nappers. The replacement nappers are much more variable as to when they go to bed and how long they sleep. There was a tendency for them to have gone to bed a little later "last night" (i.e., the night before they filled out this questionnaire) than the non-nappers ($t = 1.60$; $p < .20$), or at least at a more variable time ($F = 3.95$; $p < .01$). Thus it is still possible that while the replacement nappers typically sleep at the same time as non-nappers, there are occasions when they get less sleep. Presumably, such occasions are more likely to be associated with a nap the next day. In this data there is no way to evaluate whether either kind of napper receives more sleep in a 24-hour period than non-nappers.

While nappers and non-nappers overall do not differentially report *sometimes sleeping too long*, consistent nappers are less likely to say so than consistent non-nappers ($t = 2.56$; $df = 211$; $p < .02$). This is primarily due to the consistent replacement nappers who *less often* have the experience of having slept too long than either non-nappers ($t = 2.92$; $df = 168$; $p < .01$) or appetitive nappers ($t = 1.80$; $df = 198$; $p < .10$). In contrast, replacement nappers report significantly more often having the feeling of having slept for too short a time, compared to non-nappers ($t = 3.32$; $df = 377$; $p < .001$). Although this difference does not achieve significance with the selected consistent subgroups, the evidence indicates a subjective sleep-need pressure on replacement nappers who feel that they need more sleep, particularly under conditions

where they feel they do not often sleep enough, or for too long, but more often come up on the short side of what they perceive they typically need. This subjectively perceived need for more sleep presumably provides the basis for the replacement nappers' need to obtain naps.

One curious result is that consistent appetitive nappers are more likely to sleepwalk ($t = 2.49$; $df = 198$; $p < .02$) and sleeptalk ($t = 1.36$; $p < .20$) than replacement nappers. The mechanisms of sleepwalking and sleeptalking are not currently well understood; however the possible psychodynamic origins of these phenomena are possibly consistent with their incidence in subjects whose sleep may, in part, have psychodynamic overtones.

While the consistent non-nappers were selected in part because of the unsatisfying nature of their occasional naps--in terms of physical and mental functioning--such a negative attitude does not relate to their sleep in general. The non-nappers did not differ from either group of nappers on ratings of how satisfying night sleep tends to be, nor on how deeply and well they typically sleep. Replacement nappers report that sleep is slightly more satisfying ($t = 1.79$; $p < .10$), and they relatively less often have difficulty falling asleep ($t = 2.27$; $p < .05$) than appetitive nappers. This finding is surprising, though in general difficulty sleeping is not related to napping or non-napping as such.

Napping in Appetitive and Replacement Nappers

Voluntary Control of Napping. As already noted, nappers report a capacity to fall asleep readily in a variety of circumstances. Table 3 compares the appetitive and replacement nappers in terms of the rated ease of falling asleep under several conditions. The mean values represent ratings on a 5-point scale.

Appetitive nappers tend to nap more than replacement nappers while reading a book ($p < .05$), while studying ($p < .10$), during a play or at the theater ($p < .05$), and have a similar but insignificant tendency during lectures and speeches and after a particularly good meal. In contrast, replacement nappers are more capable of falling asleep on long car trips ($p < .10$) and on plane or train trips ($p < .05$). While we do not fully understand the significance of the advantage held by the replacement napper under these two circumstances, both involve extended motion. The relationship between volitional and involuntary naps and the physical environment will be explored in future work: It is also possible that the replacement nappers plan their sleep knowing that they will be able to catch up on or following the trip.

Of particular importance was the striking tendency for the appetitive nappers to say that they tend to fall asleep at times of stress compared to either the replacement nappers ($t = 2.43$; $p < .01$) or non-nappers ($t = 3.36$; $p < .005$). This provides important confirmation of the appetitive nappers' tendency to fall asleep in response to psychological factors, as

opposed to factors relating to general fatigue or sleep deprivation.

When the extreme ratings of "5" are summed over all ten categories, the appetitive nappers show a greater ability to voluntarily fall asleep under a variety of these circumstances significantly more frequently than the replacement nappers ($t = 1.98$; $p < .05$). However, as already indicated both groups differ markedly ($p < .001$ in each case) from the non-nappers in their ability to nap frequently in a wide variety of circumstances.

Nap Satisfaction. In Table 4 mean ratings of the subjective satisfaction with napping for the appetitive and replacement nappers are summarized. These differences refer to part 3 of the questionnaire which was only completed by the napping subjects. The data compares both consistent appetitive ($N = 43$) and replacement ($N = 156$) nappers.⁴

In general, the results show that the appetitive napper has a greater propensity for napping and finds napping more desirable than the replacement napper. The appetitive napper rates himself as more often taking naps ($p < .05$) and he, in fact, naps more frequently ($p < .05$). He rates himself as preferring to nap daily ($p < .02$). He likes to nap as regularly as possible ($p < .02$) and voluntarily naps whenever time permits ($p < .002$). When asked how long after awakening from a nap he would be ready for another nap, his answer is sooner than for the replacement napper ($p < .10$). The appetitive napper naps in a wider variety of circumstances ($p < .05$), although there is a slight tendency that he

TABLE 4

Differences in Subjective Sleep Characteristics
for Consistent Appetitive and Replacement Nappers

Variable	Appet. Napper (N=43)	Replace Napper (N=156)	<u>t</u>	<u>p</u> <
Take catnaps	3.51	3.26	2.16	.05
Nap frequency per month	16.91	12.79	2.13	.05
Hours till could nap again	4.14	4.54	1.40	.10
Could nap daily	3.30	3.00	2.40	.02
Like to nap regularly	3.14	2.80	2.31	.02
Voluntarily nap if time	3.53	3.17	3.23	.002
Feel more tired awake	2.21	1.95	1.81	.10
No nap if regular sleep	2.70	3.44	3.25	.0002
Nap when <u>not</u> tired ^a	3.12	1.35	29.11	.0001
\bar{X} "Always" response-- case of sleep	1.49	1.04	1.98	.05

Note.--All questions 5-point scale where 5 represents high (always) end (except second and third variable).

^a Selection variable.

will feel more tired when he awakens than does the replacement napper ($p < .10$). However, it is important to note that the replacement napper is much less likely to nap if he considers he has had a regular night's sleep the previous night ($p < .0002$).

Differences on all other variables listed in the third part of the questionnaire were not significant. This includes such characteristics as whether the subject would prefer to obtain all of his sleep in one continuous segment or whether he would prefer to sleep on demand whenever tired, and the effect of napping in improving the subject's ability to work or his ability to concentrate. There was no significant difference in the tendency to nap involuntarily. In the situations referred to above the subjects mostly decided voluntarily to take a nap. The results do not necessarily refer to situations where falling asleep is not premeditated.

It is clear from these results that the appetitive napper can more readily take naps in a variety of situations and generally has the set that he is willing to nap and is capable of napping whenever he chooses to do so, and wherever circumstances permit.

Estimated Parameters of Napping. Table 5 presents the mean reported times that all nappers, appetitive as well as replacement, take their nap and how long they nap. There are no significant differences between appetitive and replacement nappers in terms of these estimated clock parameters. Subjects prefer to nap at about 3:49 p.m.,

TABLE 5

Estimated Parameters of Napping in Consistent
Appetitive and Replacement Nappers

Variable	All Nappers N=261	Consistent Nappers	
		Appetitive N=43	Replacement N=156
What time prefer to nap	15:44	15:52	15:48
How long would the ideal nap last	98.96	101.30	99.86
What is the longest time you nap	162.82	163.60	156.79
What is the shortest time you nap	24.78	24.84	25.14
When napping, how long to fall asleep	9.75	8.56	9.19
When nap, how long typically last	73.35	81.23*	70.40*

Note.--The first variable is reported in hours and minutes (24-hour clock-time). The remaining variables have been converted to minutes: Subjects typically recorded their answers to the nearest 15 minutes.

* Comparison of subgroup variances: $F = 2.59$; $df = 42, 155$; $p < .001$. All other t-test and F-ratio comparisons between appetitive and replacement nappers are insignificant.

and the typical nap lasts about 73 minutes. However, the length of the typical nap in appetitive nappers is much more variable than in replacement nappers ($F = 2.49$; $df = 42, 155$; $p < .001$). While the typical nap is about 73 minutes, the average longest nap subjects report is 158 minutes, although subjects consider the ideal nap would last 100 minutes. It takes a napper an average of 9 minutes to fall asleep when he is having a nap; this is in striking contrast to the typical 20 minutes it takes the same subjects to fall asleep at night.

In general, in spite of the differences in the reasons for napping, there are no differences in the time the two groups of subjects take their nap and the length of the longest, shortest, typical, or ideal nap.

Why Does the Non-Napper Not Nap?

The second part of the questionnaire was completed only by the non-nappers; those subjects who responded "rarely" or "never" to the question on part I, "Do you take catnaps during the day?" This part of the questionnaire was concerned with questions about the reasons for not napping and attitudes towards napping.

The non-nappers were asked "Was there a period of time when you did take naps at least sometimes?" Of the 169 non-nappers, 41 answered "No." An additional 48 subjects answered "Yes," but in response to the question "When?" gave such modifying responses as "When I was a child" (defined when necessary by us as before 12 years of age), "When pregnant," "When ill." These were considered as inconsequential to

our non-napping criterion, and a subject giving this modified "Yes" answer was included as a consistent non-napper if he satisfied all of the other criteria. In fact, 7 of the 13 consistent non-nappers were selected from this subgroup. The remaining 80 subjects responded that they did once nap, but did not modify their statement in terms of the kinds of special circumstances noted above. Analysis of variance comparing the four subgroups consisting of the consistent non-nappers, modified non-nappers, those who once napped regularly, and the remaining non-nappers who did not qualify for the laboratory study, yielded very few differences among the groups. There were some differences in the reasons given for not currently napping (discussed below) and some additional differences between consistent non-nappers and those subjects who once napped regularly, but now no longer do so.

All non-nappers were given the opportunity to rate on a 5-point scale (5 = Definitely applies; 1 = Irrelevant), each of 15 different reasons why they preferred not to nap. The possible reasons included the inability to sleep when attempting to nap, interference with night sleep, interference with daytime activities, and the unpleasant results of daytime napping. The three reasons most strongly endorsed by all 169 non-nappers were: "Napping interferes with my work (or studying)," "No time available," and "I would not be able to fall asleep."

The consistent non-nappers in this study were chosen because they stated that previous napping typically had unpleasant physical and mental aftereffects for them. Apart from these reasons the three most

common reasons they checked for not napping were related to these unpleasant consequences: "I did not feel any better after napping," "I did not feel any less tired after napping," and "Napping is an unpleasant experience." The three reasons which least affected their reasons for choosing not to nap were "Napping is a sign of laziness," "If I napped I would not be able to sleep well at night," and "No time available." Thus, while it was decided in the laboratory study to select non-nappers who did not nap because of the unpleasant consequences, these subjects were not necessarily typical of a larger proportion of non-nappers who consistently did not nap primarily for reasons of lack of time. Particularly interesting in this regard was the 80 of the 169 subjects who indicated that they once napped after childhood, but no longer did so. These subjects now no longer napped because they had no time to do so, and because napping interfered with study and/or leisure activities. The unpleasantness of the nap does not seem to have been an important reason for their discontinuation of napping.

A detailed comparison of the 13 consistent non-nappers and the 80 non-nappers who once napped is presented in Table 6. The several significant differences between these two groups are all in the direction of either there being no time for napping for the once-nappers, or because of the unpleasantness of napping for the selected group. These results would strongly suggest that future work needs to consider the problem of non-napping more extensively than we did in the empirical laboratory work conducted during the past year. Non-napping is not a homogeneous

TABLE 6

Differences (on 5-point rating scale) Between
Non-Nappers (N = 13) and Subjects Who Were
Once-Nappers But Are No Longer Nappers (N = 80)

Variable	Consistent Non-Nappers	Once-Napper	t	p <
Take catnaps	1.54	1.96	2.98	.01
No time to nap	2.54	3.50	2.57	.01
Nap unpleasant experience	3.46	1.84	7.31	.0001
No need for nap	3.15	2.51	1.67	.10
Interferes with work, study	2.85	3.56	2.10	.05
Don't feel better after nap	3.69	2.64	2.43	.02
Don't feel less tired	3.54	2.64	2.61	.01
Unpleasant physical effect	3.92	2.31	6.15	.0001
Unpleasant mental effects	3.62	2.11	5.07	.0001
Fall asleep on car trips	2.23	2.94		
Ease of sleeping in many situations*	.31	.74	2.17	.05
Time usually most sleepy**	21:19	17:64	2.13	.05
Time prefer to sleep**	00:21	23:22	2.33	.05

Note.--Answers rated on 5-point scale: 5 = Always, 1 = Never.

* Mean sum of "always" answers on 14 listed reasons for not wanting to nap.

** 24-hour clock-time - hours and minutes.

entity, but different kinds of non-nappers would seem to have different kinds of characteristics. Whether such subgroups would differ in terms of the subjective and physiological characteristics of daytime sleep in the laboratory remains to be investigated.

Many of the responses of the non-nappers who once napped on the first section of the questionnaire tend to be more like the responses of the replacement napper group. Typically, the means of the non-napper groups fall somewhere between the consistent non-nappers and the consistent replacement nappers. We surmise that most of these subjects were once replacement nappers who, because of time and scheduling reasons, have had to learn to assert better control over their sleep activities and to avoid being caught in a situation where napping is necessary to make up for lost time. It is interesting that in spite of the restricted range on the criterion catnap question, the once-nappers still nap significantly more often per month than the selected group of 13 non-nappers (1.96 versus 1.54 times per month, $t = 2.98$; $p < .01$).

Summary

In general these data support most of our predictions about the characteristics of napping and also about the different kinds of nappers. Somewhat surprisingly, there were absolutely no differences in the basic sleep parameters reported by subjects regarding typical nighttime sleep habits. Although nappers report they can fall asleep more easily than non-nappers, they did not differ from non-nappers in clock time estimates of

how long it takes them to fall asleep at night. However, there was substantial evidence that nappers have a greater facility to fall asleep easily and to voluntarily choose situations in which they can sleep. Nappers, and particularly appetitive nappers, are capable of sleeping in a variety of circumstances, many of which have little or nothing to do with tiredness or fatigue.

Our concept of appetitive and replacement nappers appears to have some validity. Appetitive nappers have a greater degree of control over the ease of falling asleep and tend to nap more frequently than replacement nappers. In particular, they are more likely to nap in response to stress, but they do not necessarily feel more refreshed or less tired when awakening from a nap. In contrast, replacement nappers are much more variable in terms of when they go to sleep and get up in the morning, and how long they sleep at night. They are not likely to nap if they have had sufficient sleep the previous night and they typically report feeling less tired after they nap. Apparently, napping for the replacement napper has the desired recuperative effects from fatigue resulting from loss of sleep.

Subjects who typically do not nap may well be more heterogeneous than we had anticipated. There are at least two types of non-nappers; the group we focused on in this study are subjects who do not nap because of the unpleasant consequences they have experienced when they tried to nap in the past. They do not believe they gain any benefit from napping. There is, however, another group of subjects who do not nap

because of time considerations rather than any dissatisfaction with the experience. Many of these subjects have napped more frequently in the past than they do now. Although the data is limited, it would seem that they share some of the characteristics of the replacement nappers in the present sample. However, the focus of this report will be on the non-nappers who find the consequences of napping are unpleasant and non-recuperative.

3. LABORATORY NAPPING STUDY

The primary aim for the past research period was to examine some of the subjective and physiological changes when habitual nappers and confirmed non-nappers were asked to nap in the laboratory during the day while being monitored by standard EEG and sleep laboratory procedures. We were able to capitalize on the extensive study of napping patterns by using those extreme subjects who enjoyed napping frequently or who consistently avoided napping because of the unpleasant effects associated with daytime sleep.

Subgroups of nappers were chosen who seemed to represent, by their questionnaire responses, either those who napped primarily to replace lost sleep, or those who seemed to nap primarily for a variety of reasons having little or nothing to do with fatigue. In addition, we explored, in terms of reported sleep patterns, some issues related to the incidence of napping in relation to both the previous and subsequent night's sleep, as well as to regular sleep patterns.

Because morning, afternoon, and evening naps differ in terms of the incidence of REM and stage 4 sleep (Maron et al., 1964; Webb & Agnew, 1967; Webb et al., 1966), the laboratory nap was confined to the afternoon period. The subjects' naps were restricted to one hour, as this seems to be the modal nap length reported by college students (Tune, 1969a; Lawrence, 1971).

Laboratory Nap Procedure

Recruitment of Subjects. From a total of 946 napping questionnaires, each of 114 subjects, who not only qualified as nappers or non-nappers according to the criteria described above but also had expressed interest in taking part in laboratory sleep research, were sent a letter inviting them to participate in a three and one-half hour study in the laboratory. If they were interested in participating, they were asked to call to make an appointment. When a subject telephoned, further background information was secured. If the subject had not participated in previous psychophysiological research in the laboratory or in sleep research elsewhere; if he was not currently in psychotherapy, had not been in therapy within the last six months, and was not contemplating therapy; if he was between the ages of 18 and 37; if he learned English prior to the age of 10; and if he was not taking any medications daily, the present experiment was described to him.

"The purpose of this experiment is to investigate the physiological events associated with sleeping in the daytime. The study involves attaching several small electrodes to your head. These electrodes are very small disks, just about the size of a dime, which are attached only to the surface with water soluble paste. Other similar small electrodes will be attached to your hands and

chest with easily removable tape. We will then record from these electrodes while you take a brief nap in the laboratory."

Because the sample included non-nappers, questions occasionally arose over the telephone whether the subject felt he would be able to nap in the laboratory. In order to prevent undue concern about being able to sleep, which in turn might interfere with the individual's ability to do so, the question (when it arose) was handled as follows: The scheduling assistant emphasized that while we had found, when time was set aside for that purpose, most subjects were able to go to sleep in the laboratory, it was not essential for the success of the study that they necessarily fall asleep; rather, so long as they were able to rest comfortably they would be providing valuable physiological data needed for the study.

No subject was scheduled earlier than 11:45 a.m., nor was any subject scheduled after 5:45 p.m. Thus, the earliest nap in the study began at 12:45 p.m. and the latest by 6:45 p.m.; while the arranging of the time for each laboratory nap session had to be within the limits of the subject's schedule and his preference for when he usually napped, a generally successful attempt was made to schedule most subjects between 1:30 and 4 p.m.

Each subject was offered \$5.25 plus \$.75 for transportation for the three and one-half hour session. All subjects received a letter reminding them of their appointment two to three days before their

scheduled session. The letter also stated that no medications (either relaxants or stimulants) or alcohol should be ingested within 24 hours prior to their scheduled session, that from the time they arose on the morning of the day of the experiment they should not take any rest or nap prior to arriving at the laboratory, and that while coffee or tea was all right on arising, they should refrain from either after 9 a.m. on the day of the study.

Procedure. When the subject arrived at the laboratory, he completed and signed a Background Information for Participation form which includes the standard informed consent statement used in the laboratory. He also completed another sleep questionnaire⁵ further exploring his general sleep habits. This questionnaire was designed to assess subjects' standing on several dimensions of sleep satisfaction which we reported last year.

The subject was then introduced to the first of three investigators^b who spent some time explaining in detail the purpose of the study. The aim of this procedure was to establish rapport with the subject, to explain the functions of the research laboratory, and to inform him about the laboratory sleep study. Again an attempt was made to reassure the subject that, while the aim of the investigation was to study aspects of daytime sleep, the subject should not be unduly concerned about how long it took for him to fall asleep or even if he had difficulty in falling asleep, as his resting comfortably provided important data for the study. This point was made during the interview with all

subjects, but was designed primarily for the protection of the non-nappers, some of whom were expected to be unlikely to fall asleep. The subject was not told how long he would have to sleep or rest, although he knew the total length of the session to be three and one-half hours. He was also not informed what criteria had been used to select subjects. The subject then completed the long version of a questionnaire which explored in detail typical sleep patterns and a variety of variables associated with sleeping. Three of the eight pages of this questionnaire constituted the sleep diary described below, and only data from these pages are discussed in this report.

Physiological Recordings. The subject was then introduced to the investigator conducting the sleep session. He was given the Subjective Sleepiness Scale. This is a 10-point unidirectional scale on which the subject marked how sleepy he felt at that particular time. The Position 1 on the scale was labeled "wide awake" and the Position 10 was labeled "the need for sleep is overwhelming; sleep is unavoidable."

Standard sleep monitoring electrodes were explained to the subjects as they were applied. Right parietal, right and left occipital EEG electrodes (C4, 04, and 03) were referred to the corresponding mastoid using Beckman bio-potential mini-electrodes. The same electrodes were used to record EOG from the left and right outer canthus to the nasion. These were the main variables involved in the scoring of the

sleep records. In addition, heart rate was recorded using leads from the left clavicle to the left ventral region below the ninth rib, and skin potential was recorded using silver silver-chloride sponge electrodes attached on the left hand at the hyperthenar eminence to a drilled site on the dorsal arm near the elbow. In male subjects, abdominal and thoracic respiration were also measured with strain gauges. In females, respiration was measured using a slightly different method allowing the strain gauge to go over clothing. In addition, for females finger pulse was recorded instead of heart rate, using a LED-photo transistor on the third finger of the left hand, first phalange.

The subject was encouraged to make himself comfortable in the bed and, after the lights were turned out in the dark sound-attenuated sleep room, the Subjective Sleepiness Scale was administered again and oral temperature was also recorded. A two-minute eyes closed baseline alpha-density period was recorded before the subject's nap period began.

After 60 minutes elapsed, the subject was awakened by a loud buzzer. In accordance with the previous instructions given to the subject, he was to immediately pick up a bedside telephone to turn off the buzzer and indicate that he was awake. His reaction time from buzzer onset to picking up the telephone was recorded as one possible measure of the difficulty he experienced in arousing and orienting himself. This was also compared subsequently with his EEG arousal latency from when the subject was still asleep at the sound of the buzzer until the

appearance of alpha activity. The subject was immediately asked "How long since I spoke to you last?" and then to make his rating on the Subjective Sleepiness Scale. The subject was then given an evaluation booklet containing a fourth Subjective Sleepiness Scale, a similar scale rating how satisfying the nap was, and related information describing the nap. After the electrodes were removed, he was introduced to a third investigator who conducted the post-experimental inquiry.

Post-Experimental Interview. Crucial to the design of the study, this inquiry was carried out by an experimenter who was kept blind as to whether the subject had slept (according to EEG criteria) during the experiment, as well as to the nature of the subject's original questionnaire responses and categorization prior to the experiment.

The interviewer's task was to independently assess the subject's sleep patterns and napping history. While the napping questionnaire was designed to help identify confirmed non-nappers, replacement, and appetitive nappers, it was not expected that the questionnaire responses would be sufficient as the sole criterion to select representative subjects in each category. In the final analysis, a carefully conducted individual interview was felt to be the best available means of validating the classification criteria. For this reason, subjects were retained in the study only if the blind judge's assignment based on the interview coincided with the categorization on the basis of the questionnaire.

From the point of view of efficiency it would, of course, have been

simplest to carry out the inquiry into sleep patterns before deciding which subjects were to be invited to the laboratory. However, every effort was made not to focus the subject's attention unduly on the importance of sleeping in the laboratory; i.e., the sleep questionnaire had been administered as a parametric investigation and care was taken not to connect the subject's responses to the request to participate in a laboratory sleep study--which was usually made weeks later. In our view, to carry out an interview focusing on daytime sleep patterns prior to the subject's sleeping in the laboratory would have tended to prevent non-nappers from sleeping and might also have brought about other unforeseen and undesired changes in subject behavior. It seemed a reasonable trade-off to accept the relatively inefficient procedure of carrying out a criterion interview after the individual had slept in order to make it relatively easy both to keep the laboratory staff blind as to the subject's status and prevent undue concern on the subject's part about his ability to sleep during the experiment.

The interview typically lasted about 35 minutes. While the interview was as nondirective as possible, it eventually proceeded to more specific questions, depending on the information already elicited spontaneously from the subject in his comments about his experiences in the study and his previous history of napping.

Results of Blind Categorization. There were 52 subjects⁷ who completed the laboratory sleep study of which 7 were excluded for technical reasons.⁸ In 33 instances the blind judge's categorization

was the same as that based on the questionnaire and these subjects therefore met the criterion of the study. Nine of the 12 discrepant instances⁹ were from the same group and may represent a special subcategory of nappers. The 33 subjects¹⁰ who qualified for the experiment and were studied in depth included 11 appetitive, 10 replacement, and 12 non-nappers.

Sleep Diary. At the completion of the interview, the subject was thanked and paid for his participation. However, before he departed, he was invited to take part in a continuation study. He was told that it would be helpful to have more detailed day-by-day information regarding sleep habits, and he was invited to take home a binder containing 14 copies of a three-page sleep diary questionnaire (a copy is in the Appendix). If the subject agreed, he was asked to complete one of the questionnaires each morning for the next 14 days, preferably shortly after getting up. When completed, the diary was to be mailed back to the laboratory in the stamped, addressed envelope provided. While prior to the request to complete the diary it had been explained that the laboratory napping study was complete in itself, no subject refused to take home the sleep diary. Subjects were paid an additional \$5 in advance for their time in completing the sleep diary.

All except 3 of the original 52 subjects returned the completed sleep diaries. However, in a few instances the diaries were not kept on consecutive days, either because of interruptions caused by college

vacation periods, conflicting schedules, or forgetfulness. All subjects completed the diaries the day after they had slept in the lab and most of the diaries were completed in a minimum of two consecutive periods, even if there was a delay somewhere in the middle of the period. Only those returned by the 11 appetitive, 10 replacement, and 12 non-napper subjects will be reported here.

Sleep Protocols. All of the sleep psychophysiological records were scored independently by two judges who were blind as to the subgroup membership of the subjects. The records were scored in 30-second epochs according to the standards defined by Rechtschaffen and Kales (1968). Discrepancies were resolved by a third independent judge.

Results

Laboratory Napping: Physiological Concomitants of Napping

EEG Sleep Onset. It had been predicted that individuals who met the criteria for nappers, either appetitive or replacement, would sleep more in the laboratory situation than non-nappers, and that differences in sleep patterns would be observed between the groups. We were surprised at how readily many of the non-nappers actually slept, considering both the laboratory conditions and their normal tendency not to sleep

during the day. In fact, only 3 of the 12 non-nappers failed to sleep during the 60-minute period according to the standard EEG criteria. In addition, 1 of the 10 replacement nappers did not fall asleep. Because of the undue influence of non-sleep on many of the relevant sleep parameters, and as the emphasis was on the nature and effects of napping, the failure to sleep in these few subjects is noted, but (unless specified otherwise) these subjects were eliminated from the following analyses. Thus, the data below is based on 11 appetitive, 9 replacement, and 9 non-nappers. Basic parametric data in terms of length of time in various sleep stages, and the number of distinct epochs of each sleep stage separated by at least 30 seconds of a different stage, are presented in Table 7.

Both appetitive (13.6 minutes) and replacement (11.6 minutes) nappers fell asleep more quickly, defined by the initial onset of stage 2 spindles, than non-nappers (25.7 minutes; $p < .02$; $p < .01$, respectively). Thus, our main prediction concerning the greater readiness of nappers to fall asleep on demand was confirmed in the laboratory nap using physiological criteria, just as it had been repeatedly confirmed from the questionnaire data.

There are secondary ways in which sleep onset can be observed, particularly by the appearance of slow rolling eye movements (SEM) which is usually coincident with the onset of desynchronization of alpha (Oswald, 1962; Paskewitz & Orne, 1972), and with the initial onset of stage 1 sleep marked by the totally alpha free desynchronized

TABLE 7
Parameters of EEG Sleep in Nappers and
Non-Nappers During 60 Minute Daytime Nap

EEG Variable	Non-Napper N=9	Appet N=11	Replace N=9	t-tests [*]
Sleep onset (mins.)	25.7	13.6	11.6	N > (A, R)
Time in Stage 1	3.4	8.1	4.4	A > (N, R)
Time in Stage 2	16.5	16.0	18.6	
Time in Stage 3	13.1	15.7	19.0	
Total sleep time	33.0	39.8	42.0	R > N [*]
No. of Stage 1 epochs	2.7	7.0	2.6	A > (R, N)
No. of Stage 2 epochs	1.3	2.6	1.9	A > N
No. of Stage 3 epochs	0.6	0.9	0.8	
No. of awakenings > 3 min.	0.1	0.6	0.4	A > N [*]

Note: All differences $p < .05$ or better, except where * indicates $p < .10$ for specific comparisons. Groups enclosed in parentheses indicate that each of the subgroups differs from the other group(s) opposite the inequality sign.

fast amplitude EEG. For both appetitive and replacement nappers the onset of SEM (after 7.50 and 6.71 minutes respectively) and the onset of stage 1 (after 8.36 and 6.54 minutes respectively) was significantly faster than for non-nappers (SEM: 21.6 minutes; Stage 1: 23.7 minutes; $p < .002$ for all comparisons). However, in spite of the similar total length of time asleep, discussed below, stage 1 onset lasted for 3 and 5 minutes for appetitive and replacement nappers, but only 1.4 minutes in non-nappers. Incidentally, while this was almost all of the stage 1 obtained by non-nappers and particularly replacement nappers, it was only about 55 percent of the stage 1 sleep obtained by appetitive nappers. Some significant aspects of this finding will be discussed below.

Sleep Stages. There were no significant differences between the total length of sleep (either including or excluding stage 1 onset in the definition of sleep) or time spent in stages 2 and 3 among the three groups. Even though nappers fall asleep more quickly in the laboratory, their nap is not necessarily longer than that of non-nappers. However, at least for the appetitive napper it is quite different in its structural characteristics. Many of these features can be seen in the sleep profiles for a typical subject; a representative example for each group is shown in Figure 1.

Appetitive nappers had an average of 8.1 minutes of stage 1; significantly more than the 4.4 and 3.4 minutes obtained by the replacement napper and the non-napper subgroups respectively ($p < .10$; $p < .05$).

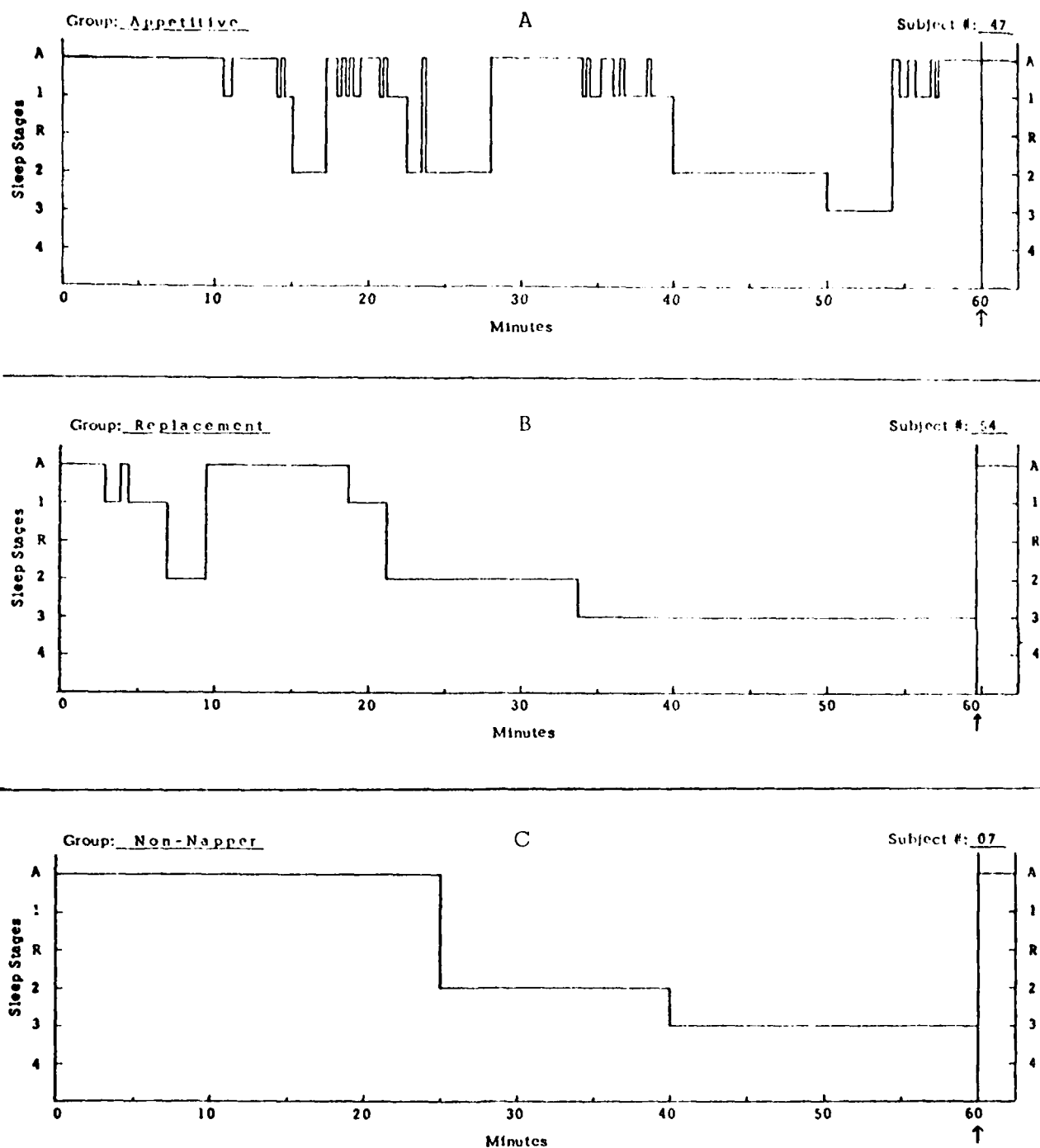


FIGURE 1

Sleep Profiles for an Appetitive Napper (A), a Replacement Napper (B), and a Non-Napper (C)

These sleep profiles are for the 60-minute laboratory nap period for typical subjects. Length of time is plotted in each of EEG-sleep stages (defined on vertical axis): Awake, Stage 1, Stage REM, Stage 2, Stages 3 and 4 (delta) sleep.

There were typically 7 such epochs scattered throughout the nap, compared to less than 3 each for the remaining 2 groups ($p < .05$; $p < .05$ respectively). While 10 of the 11 appetitive nappers showed this cycling phenomenon (as rated by a blind judge) only 9 of the remaining 25 subjects showed it (exact $p < .01$).

Differences in the occurrences of stage 1 and the tendency to cycle through light sleep stages noted in nappers in our earlier report were confirmed in the present study. These earlier results are further clarified because it is clear that it is almost entirely the appetitive nappers who cycle repeatedly through stage 1. Stage 1 is sometimes referred to as drowsiness, or sleep onset, and is frequently associated with the hypnagogic reveries that accompany sleep onset.

The appetitive napper has more epochs of stage 1 in his nap, and as a result he spends more time in stage 1, particularly after sleep onset, than other subjects. However, he also has more epochs of stage 2 and stage 3 than other subjects. The appetitive napper's sleep is therefore quite cyclical, relatively unstable or poorly developed in terms of the usual orderly progression of sleep records. He has more than 11 changes in sleep stages in 40 minutes of sleep, compared to only 4 or 5 such changes in the 33-42 minutes of sleep of the other subgroups. Lawrence (1971) also noted a high frequency of sleep stage changes in her study, but it now seems clear that this cyclical, perhaps lighter sleep is experienced primarily by the appetitive napper.

While the tendency toward rapid cycling between stage 1, 2,

and awake is particularly pronounced among appetitive nappers, no data is available which might clarify the reasons for this interesting psychophysiological response pattern. It is possible that for the appetitive napper in particular the greater amount of time spent in stage 1 as a consequence of cycling allows for more hypnagogic reverie which, in turn, may satisfy psychological rather than biological needs.

Observations made in the previous sample, where it was seen that even brief periods of napping significantly reduced anxiety and increased surgency in habitual nappers, may be relevant. Anecdotal data would suggest that these kinds of naps may facilitate problem solving.

Another aspect of cycling would seem to be that it allows the individual to remain in light stages of sleep and remain vigilant vis a vis his environment. In delta sleep, auditory thresholds for awakening increase greatly compared to stages 1 and 2; further, significant performance decrements are seen immediately on awakening from delta epochs--while no such decrements occur when an individual is awakened from stage 1 or 2.

Previously it was suggested that one of the possible differences between habitual nappers and non-nappers was in the incidence of delta sleep. Further, there was some indication that nappers who entered delta sleep during a relatively brief nap reported that particular nap as an unsatisfactory experience. It seemed plausible, therefore, that habitual nappers had learned to inhibit delta sleep in brief naps while non-nappers failed to inhibit delta sleep during a brief nap, and the

consequent discomfort would account for their wish to avoid napping in its entirety. In the present study we have been unable to document an association between dysphoric affect on awakening and the presence of delta sleep. This may in part be related to the somewhat longer period--one full hour--which was available for the subject in this instance.

Another difference between the present and the previous study which had initially not appeared to us as important may turn out to have a very significant role. In the earlier study subjects were awakened five to twenty minutes after nap onset and asked whether they had been asleep and how much time had transpired since the light had been turned out. In retrospect, it appears that this procedure elicited cycling behavior even in partially sleep-deprived subjects. It may well be that under circumstances where the subject expects to be aroused he seeks to prevent himself from entering delta sleep. When he nonetheless does, it tends to be associated with dysphoric affect. This is, of course, an extremely tentative speculation, reflecting the serious lack of parametric information against which to evaluate the psychobiological nature of particular napping episodes. While in the present study it seems clear that napping serves different functions for the appetitive and the replacement napper, future work will need to determine what occurs when appetitive nappers are sleep deprived and thereby forced to utilize napping for replacement purposes. Self-report data indicates that appetitive nappers are able to do this successfully but as yet we lack any information about the physiology of naps in the same subjects

that are required to serve different psychobiological functions. We anticipate that as these issues become clarified we will better understand the function of delta sleep in the context of relatively brief naps.

Other Physiological Differences. In addition to sleep latency and sleep patterning, other physiological differences were noted between the groups and are summarized in Table 8.

The napper groups each had lower oral temperatures (around 98.4°) at the beginning of the nap period than did the non-nappers (98.8° ; $t = 2.35$; $df = 35$; $p < .05$). Across all groups of subjects, oral temperature declined during the nap period. This decline, however, was significantly greater for the replacement nappers ($-.44^{\circ}$) and particularly for the non-nappers ($-.61^{\circ}$). It is not clear why the non-nappers had such high initial temperatures. Since temperature normally declines during sleep, and even in the evening hours before sleep onset, it is possible that the lower temperatures of nappers was one indication of their readiness to fall asleep quickly. Alternatively, the significantly higher levels of physical activity during the 24 hours preceding the nap (both compared to their own daily average and that of other subjects) could account for the higher initial temperature of the non-nappers. This could have been the way the non-napper tried to prepare himself to be able to nap in the laboratory. It could also partially explain the sleep onset problem for the non-napper: perhaps sleep does not tend to occur until this initially high temperature is lowered.

TABLE 8

Comparison of Nappers and Non-Nappers During
Laboratory Naps on Related Physiological Variables

	Non-Napper	Appet	Replace	t-test
<u>Oral Temperature (°F)</u>				
Pre-Nap	98.79	98.48	98.38	N > (R,A)
Change after nap	- .61	- .16	- .44	N > A
<u>Skin Potential</u>				
Pre-Nap	-30.9	-43.4	-30.4	A > R [*] , N [*]
Change after nap	13.0	21.9	13.1	
<u>Alpha Density Percent</u>				
Pre-Nap	49.8	77.4	70.2	N < (A,R)
Change after nap	+9.7	+2.1	+8.3	N > A

Note: All differences $p < .05$ or better except where * indicates $p < .10$ for specific comparisons. Groups enclosed in parentheses indicate that each of the subgroups differs from the other group(s) opposite the inequality sign.

Basal skin potential at the start of the nap was significantly more negative for the appetitive nappers than for the other subjects. As expected, at the end of the nap period all groups had less negative skin potential than at the beginning, and there was no longer any difference between them. However, these electrodermal changes must be interpreted cautiously since there was a considerable amount of missing and unscorable data, particularly after the nap.

Of particular interest was the finding that nappers had greater percent time alpha than non-nappers at the beginning of the nap; once again, the change from before to after the nap observed for the appetitive nappers was less than for the other groups. Alpha density remained significantly lower for the non-nappers throughout. Incidentally, as the alpha density baselines for the appetitive nappers were so high, it seems unlikely that the light sleep cycling noted was due to difficulty in discriminating awake from stage 1 (which would be more difficult with low alpha levels).

These data suggest that appetitive nappers show less physiological change as a function of the nap than do the replacement nappers or non-nappers. This stability is in part a function of the "non-aroused" baselines at the beginning of the nap. The extent to which this contributes to the positive subjective effects of the nap for appetitive nappers is a question of considerable interest.

In general, the relatively few differences between the nappers and non-nappers in physiological variables are mostly due to the

different style of cycling sleep that occurs with appetitive nappers. The naps of the replacement napper and the non-napper were not particularly different in terms of the EEG distribution, confirming our impression that napping for replacement subjects is more typical of regular sleep.

Subjective Effects of Laboratory Naps

Sleepiness. Four times during the experiment the subjects were asked to rate, on a scale from 1 to 10, how sleepy they felt at that time. Prior to electrode attachment, nappers in general rated themselves as sleepier than non-nappers ($t = 2.21$; $df = 35$; $p < .05$). The mean initial sleepiness rating of appetitive nappers (5.35) was significantly "sleepier" than non-nappers (4.00; $p < .10$). However, replacement nappers (4.73) did not differ from non-nappers.

After the electrodes were attached, immediately after awakening from the nap, and again after electrodes were removed, there were no significant differences among the groups. The final ratings for appetitive and replacement nappers and non-nappers of 2.54, 2.44, and 2.89 did not differ significantly. However, nappers rated themselves significantly less sleepy at the end of the nap than at the beginning of it ($p < .005$; $p < .05$ for appetitive and replacement subjects). The change from pre- to post-nap sleepiness was not significant for the non-nappers.

Nappers showed a significant "waking up" effect; significant

decreases were observed between the third scale presentation immediately after awakening, and the fourth given after electrodes were removed. Thus, to the extent that these ratings can be interpreted reliably, appetitive nappers were sleepier than other subjects at the outset of the laboratory nap. All nappers were less tired after sleeping, though this was noted after they had been awake for several minutes. In general, non-nappers received no subjective benefits from the nap, feeling about the same as before it.

Depth of Sleep. No differences in ratings of depth of sleep during the nap were found between groups, whether at the end of the nap or at the deepest subjective point during the nap. That the sleep was considered to be reasonably deep was indicated by the mean 10-point scale ratings of 7.8 and 8.3 for nappers and non-nappers respectively.

Satisfaction with the Nap. After awakening, subjects were asked to report on a scale from -5 to +5 their satisfaction with the nap. The scale was presented again after electrodes were removed and subjects had moved around in the laboratory. Nappers reported being significantly more satisfied with the nap than non-nappers during both the first (+2.59 versus +0.78; $t = 4.50$; $p < .002$) and second (+2.78 versus +1.28; $t = 5.05$; $p < .001$) presentations of the scale. Thus, nappers in general expressed satisfaction with the nap, whereas the

non-nappers did not: their initial rating did not differ significantly from a zero rating, indicating a subjective neutrality about their sleep.

Appetitive nappers and non-nappers felt more satisfied after being awake for a period of time than after first awakening. However, replacement nappers did not change their satisfaction ratings.

A scale similar to the satisfaction scale, asking subjects to rate whether they were feeling worse or better as a function of the nap, was also presented twice. The correlation between the initial "satisfaction" and "feeling better" scales was .75 for the whole sample. These scales seem largely redundant from the subjects' perspective, and a parallel set of results was obtained with the "feeling better" scale.

These results seem consistent with the depth of sleep ratings, indicating that the subjects, with the exception of replacement nappers, took a little time after awakening before the positive subjective effects of the nap were noticed.

Arousal Time. An attempt was made to explore this "slow arousal" by examining two reaction time measures made immediately on awakening: (a) time taken to show any EEG signs of arousal and (b) time taken to answer the loud phone next to the bed to report their subjective sleepiness rating.

The fastest EEG arousal time was obtained in the non-napper group (0.53 seconds) though this differed significantly from only the

appetitive nappers (0.87 seconds; $t = 1.76$; $p < .10$). In fact, replacement nappers had the slowest reaction time (1.24 seconds) but as a group were extremely variable. Phone reaction time, however, was significantly faster for appetitive nappers (3.88 seconds) than for non-nappers (5.44 seconds; $p < .05$) and replacement nappers (6.92 seconds; $p < .05$).

An index of arousal lethargy could be derived as the difference between the time it took to reach the phone less the EEG arousal time. As would be expected from the subjective ratings, appetitive nappers awoke faster (3.01 seconds) than replacement and non-napper subjects (5.68 and 4.87 seconds respectively, $p < .025$; $p < .20$). As appetitive nappers were predominantly cycling in and out of drowsiness and light sleep, this is not altogether surprising.

The interpretation of these findings, however, requires considerable caution. For the combined sample of 29, speed of recovery from the nap, as indexed by the difference between EEG and phone arousal reaction times, correlated positively with whether subjects were awake at the end of the session ($.33$; $p < .05$), how tired they were before the nap began ($r = .39$; $p < .02$), and decrease in oral temperature during the nap ($r = .44$; $p < .01$); negatively with the length of time in stage 2 ($-.38$; $p < .025$) and stage 3 ($-.36$; $p < .05$) sleep, and waking alpha density both before ($-.39$; $p < .02$) and after ($-.36$; $p < .05$) the nap. The latter correlation may only mean that a measure based on EEG arousal, defined by the presence of alpha, may not be a very good

measure in subjects generating little baseline alpha.

Accuracy of Subjective Time Estimates. In our previous report we had tentatively found evidence indicating that nappers and non-nappers may be using different criteria for what they consider to be sleep, at least while napping. This evidence was derived primarily from data involving estimates of how long their laboratory nap had lasted. Averaging 5 subjects over 7 days, we found that nappers were more accurate in estimating sleep time if stage 1 onset is excluded from the EEG criteria of sleep. However, if stage 1 is included in the sleep criterion, then the non-nappers were significantly more accurate in their estimates.

The results in the present study are not as clear-cut. The present nap length was 60 minutes compared to 30 minutes for each nap in the earlier study; and the data are available for only one nap rather than an average of eight naps. In general, nap length estimates in this study were highly variable in all groups (more so in non-nappers and less so in appetitive nappers). Subjects tended to overestimate how long they had been asleep in terms of either way of defining sleep.

The discrepancies in the subjective and EEG estimates of sleep are presented in Figure 2, both excluding and including stage 1 in the definition of sleep. Allowing for the tendency toward overestimation, the trend of the data was similar to the previous

analysis; however, none of the differences between nappers and non-nappers, nor the differences between the different types of nappers, were significant--partly because of the extreme variability of these estimates. In general, appetitive nappers overestimated sleep length when stage 1 was excluded, but underestimated when stage 1 was included ($t = 9.28$; $p < .00001$). The replacement nappers underestimated sleep length regardless of how total sleep was defined. However, non-nappers overestimated sleep time by 9.3 minutes.

Subjective time estimates of sleep onset, and the number of times the subjects awakened during the nap agreed closely with the EEG data. Replacement nappers tended to overestimate the length of time it required them to fall asleep by 4.25 minutes ($t = 1.98$; $p < .10$). Appetitive nappers and non-nappers estimated sleep onset accurately within 1 minute, even though the latency to sleep onset in these two subgroups was quite different.

In general, subjects quite accurately reported the number of times they thought they awakened compared to the EEG data. However, appetitive nappers reported that they were awake fewer times than the EEG record indicated (where EEG awakenings were defined as being greater than three minutes' duration). The tendency to underestimate frequency of awakening ($t = 1.99$; $p < .10$) may be in part a function of the appetitive napper's definition of what constitutes sleep, particularly while napping.

Some Suggestive Trends from Correlational Data

We were particularly interested in determining what factors might predict whether the subject would be satisfied with the laboratory nap, and the extent to which these predictors were different for the three groups of subjects. We were also interested in which of the variables other than EEG sleep stages might differentially relate to the time spent in the different EEG stages of sleep during the nap.¹¹

Recovery from Fatigue. While several ratings of recovery from fatigue were taken, the difference in ratings on the 10-point scale asking how sleepy the subject was at the beginning and end of the session seem to best reflect recovery from fatigue. For the non-napper, only the subject's judgment (but not necessarily the EEG evidence) that he was awake at the end of the 60 minutes correlated with the magnitude of the recovery from initial fatigue ($r = .62$; $p < .10$). The longer the replacement napper felt it took him to fall asleep, the less recovery from fatigue he reported ($r = -.68$; $p < .05$). In contrast, the appetitive napper who felt it took longer to fall asleep was much less tired after napping ($r = .57$; $p < .10$), particularly if he rated himself as sleeping deeply ($r = .67$; $p < .05$), and sleeping for a long time ($r = .54$; $p < .10$). The appetitive napper also felt the nap helped him overcome his initial tiredness if he awakened slowly. Whether the feeling of being less tired was a function of the tendency to cycle and derive benefit from stage 1 mentation is not clear, but could account for the difference between appetitive and replacement groups.

Satisfaction with Nap. Subjects rated how satisfied they were with the nap on a -5 to +5 point scale after they had time to fully arouse from their nap. In general, non-nappers, as reported above, were not as satisfied with the nap as were other subjects. Higher satisfaction ratings were given by those non-nappers who had lower initial oral temperature ($r = .68$; $p < .10$), little change in alpha density from pre- to post-nap baselines ($r = .67$; $p < .10$) and rated themselves as sleeping lightly ($r = -.66$; $p < .10$). Nap satisfaction for the non-napper thus had nothing to do with EEG sleep parameters as such. Replacement nappers had a different criterion: they were more satisfied if they fell asleep more quickly ($r = -.60$; $p < .10$), had more delta (stage 3) sleep ($r = .63$; $p < .10$), and felt they slept deeply ($r = .68$; $p < .05$).

In spite of these possible differences in factors accounting for nap satisfaction, replacement nappers and non-nappers rated nap satisfaction higher if they had a slower reaction time to the phone ($r = .72$; $p < .025$; $r = .70$; $p < .05$ respectively), i.e., if it took them a longer time to respond after awakening. Similarly, the nap was more satisfying the longer the discrepancy between the EEG and phone reaction times, which we tentatively considered to be an index of temporary disorientation ($r = .87$; $p < .001$; $r = .67$; $p < .10$ respectively). It is particularly significant that neither these arousal variables, nor any physiological sleep parameters, predicted nap satisfaction for appetitive nappers, and none of the corresponding correlations even approached significance. The only two variables that correlated with nap satisfaction for the

appetitive nappers concerned the subjective passage of time. The nap was more satisfying if the subject perceived the session to be short ($r = -.68$; $p < .05$) and particularly if he felt he slept for a shorter period of time than the EEG indicated he did ($r = -.80$; $p < .01$).

For appetitive nappers, satisfaction was unrelated to depth of sleep ($r = .14$), while for replacement nappers satisfaction increased with sleep depth ($r = .68$; $p < .05$), and for non-nappers depth had a negative effect on satisfaction ($r = -.66$; $p < .10$).

At the risk of overgeneralizing, nap satisfaction seems to be a function of (a) the swift passage of time for the appetitive napper, (b) rapid onset, deep sleep and arousal disorientation for the replacement napper, and (c) metabolic factors (low temperature, EEG "relaxation," etc.) along with post-nap disorientation for the non-napper.

Predictors of EEG Nap Parameters. There were some differences between the groups in those variables which were related to the basic EEG sleep parameters recorded during the nap.

(a) Latency to spindle in sleep onset: Replacement nappers who fell asleep quickly were more satisfied with the nap ($r = .74$; $p < .01$), but woke up more slowly ($r = .80$; $p < .0025$). Non-nappers who fell asleep quickly had less sleep the previous night ($r = -.62$; $p < .10$). None of the physiological variables investigated predicted sleep onset for appetitive nappers.

(b) Time in stage 1 sleep: Replacement nappers who

obtained more stage 1 were more tired before the nap ($r = .72$; $p < .02$), and awoke more slowly ($r = .80$; $p < .0025$). Non-nappers with more stage 1 also awakened more quickly ($r = -.66$; $p < .10$). Again, there were no correlates of stage 1 in appetitive nappers, except that the amount of stage 1 correlated .80 ($p < .002$) with the number of stage 1 epochs--a reflection of the appetitive napper's tendency to cycle through light sleep during his nap.

(c) Time in delta (stage 3) sleep: Replacement nappers with the most delta sleep reported they slept more deeply ($r = .66$; $p < .05$), felt more satisfied ($r = .63$; $p < .10$), awakened more slowly, and experienced more disorientation. There were no important correlates of delta time for appetitive nappers and non-nappers.

(d) Total sleep time: Except where noted above, there were no important correlates of total sleep time.

(e) Time awake at end of nap: Appetitive nappers were more disoriented at the end of the session if they had been awake for some time ($r = -.57$; $p < .10$). Non-nappers who slept longer "last night" and who had more epochs of stage 1 in their EEG nap record were more likely to be awake at the end of the session.

It is, of course, not possible to tell how much we should rely on these correlations, based on extremely small samples and capitalizing on unknown degree or chance fluctuations, where the deviant response of even only one subject can radically alter the magnitude of a correlation. At least most of the results highlighted above seem consistent

with other characteristics of the different types of subjects outlined throughout this report. Such data provide the basis for additional hypotheses regarding napping that can be tested empirically in later studies.

4. 15-DAY SLEEP DIARIES

The subjects who participated in the laboratory napping study completed a sleep diary questionnaire for 14 days after the napping session. Their first home diary report was always completed the day after they had participated in the laboratory nap study.

There were several aims during this part of the investigation: (a) We were interested in the day-by-day variation in such variables as sleep length and onset, and the quality of sleep. There are a few scattered studies which have had subjects in different populations report daily sleep patterns. The recently available thesis by Lawrence (1971) is probably the most comprehensive. (b) The diaries allow us to compare daily sleep patterns in napping groups, and provide a means of confirming the validity of some of the statements made in the original napping questionnaire in which "typical day" ratings and estimates were made. The adequacy of such data depends largely on the care with which such diaries are kept. (c) We wished to explore the relationship between the occurrence of napping and its effects on nighttime sleep patterns. This involved two kinds of data. First, we examined the effect of the laboratory nap on the subsequent night's sleep. There are a few studies exploring the EEG stages of night sleep in terms of whether naps occurred at certain times during the day. (Karacan et al., 1970b), but we were primarily concerned with the subjects' self-reported patterns rather than, at this time, EEG-monitored night sleep. Only limited aspects of

Kleitman et al.'s (1937) early study bear on this question. While these few studies attempted to investigate the effects of napping on the subsequent night's sleep, no studies have addressed the relationship of the previous night's sleep patterns and napping. Such data are likely to shed light on possible reasons why subjects choose to nap, or not to nap, on a certain day.

An exploration of these issues was expected to clarify some of our earlier results as well as providing some insights regarding when and why some people nap some of the time and what attributes can be meaningfully isolated that affect its incidence and enjoyment.

The problems of obtaining reliable self-report data of this kind are well appreciated, and given the small samples of the present study, although compensated for in part by how carefully the subjects were selected, render this an exploratory investigation at best. Nevertheless, such an intensive sleep diary over even two weeks has infrequently been reported in the literature, except in the specific context of collecting remembered dreams, and we know of no similar attempt to keep any consecutive records related to napping behavior.

General Procedure

The special sleep diary was derived from the Patterns of Sleep Questionnaire that we had been using in other work within the laboratory. A copy is attached in the appendix. A broad range of questions using a marked variety of item-format was employed. Some redundancy was

involved in order to check on the reliability of the reports.

All subjects filled out the longer version of the diary (but including the same questions asked in the same consecutive order as on subsequent days) after they first arrived at the laboratory and were introduced to the purpose of the study. It was completed before the nap period, and asked questions about the night preceding the laboratory nap, as well as the preceding day. This first completion will be referred to as the pre-nap diary. Any major variation in response from this day compared to the subsequent sequential two weeks presumably reflected in part anticipatory reactions to the nap they knew they would attempt to have within the laboratory setting.

On some rare occasions some subjects indicated some special difficulty or anticipated atypical sleep patterns (e.g., impending examination periods, special vacation periods, etc.) in which permission was given to skip a series of days, as long as this was so indicated. However, the first questionnaire was always filled in the night after the laboratory nap, and this will be referred to as the post-nap diary. The following 13 days provided a baseline describing the subjects' actual sleep parameters and habits.

Of the subjects comprising the main subgroups analyzed in the previous section, 12 non-nappers, 10 appetitive nappers (1 missing) and 8 replacement nappers (2 missing) were analyzed. The three diaries not analyzed were not returned on time, but were all eventually obtained (though they were not completed on consecutive days).

Several methods of data reduction are being conducted, but are not all completed. Pre- and post-laboratory nap days were compared for the different groups. A 13-day mean score on each variable was calculated for each subject, providing a mean baseline sleep performance for each subject.¹²

A more complex series of analyses centered on the use of "target" days. A target day nap diary was one which was filled out the morning after the subject had a nap, whereas a target no-nap diary was one filled out following days on which no nap was reported during the preceding day. A comparison of the mean performance (on a particular variable) based on all of the target day nap diaries with the target non-nap diaries allows a comparison of napping groups in terms of the consequences (on sleep parameters and satisfaction) of napping compared to not napping. The first two diary days, which preceded and followed the laboratory nap, were not, for obvious reasons, included in this kind of analysis, although separate comparisons were made of these two special days. Adopting a similar logic, the parameters of sleep which may have been determinants of the decision to nap on a particular day could be explored by analyzing the diary records completed on the morning on which the target nap occurred (i.e., referring to the day and night before the nap or non-nap took place). While this preceding night's sleep parameter may have been in turn influenced by the preceding day's decision to nap or not nap, sample sizes were too small to assume anything other than these contingencies averaged out over the two groups.

It should be noted that the napping questionnaire discussed in the earlier section concerned "typical" or "general" self-reported napping and sleep characteristics. The sleep diary asked specific questions within the same broad areas about "last night" or "yesterday."

Sleep Patterns during 15 Diary Days

Nappers versus Non-Nappers. There were relatively few differences in the day-to-day sleep patterns reported by the various groups. This result may have been anticipated in view of the results already reported showing relatively few differences in habitual sleep patterns found on the napping questionnaire. In addition, any differences that are specifically a function of napping would be minimized in such a comparison because some days on which naps occur are averaged with other days on which no naps occur. Presumably for these latter occasions, many of the napper subjects could reasonably be expected to have sleep patterns quite similar to those of non-nappers. While some specific comparisons will be made in the following section, in general, means derived from averaging responses over 15 days were quite similar and remarkably consistent with corresponding results obtained from the original napping questionnaire that asked similar questions concerning typical conditions.

Some differences between nappers and non-nappers were found which seemed internally consistent. The nappers reliably rated themselves

as being more sleepy at the time they filled out the diary than the non-nappers ($p < .02$), although there was no overall difference in the time of day the diaries were completed. They also reported that they could readily fall asleep at the time they were filling out the diaries ($p < .001$) if they had the opportunity to do so. Nappers rated themselves on a 10-point scale as sleeping better "last night" (8.36) than the non-nappers (6.86; $p \leq .02$).

Non-nappers reported it typically took them 26.8 minutes to fall asleep at night compared to 17.91 minutes for the nappers ($t = 1.96$; $p < .10$). In particular, the appetitive nappers fell asleep ($\bar{X} = 16.9$) faster than the non-nappers ($p < .05$). While these times surprised us, they compare favorably with the mean of 26 minutes latency reported by Lawrence (1971) using a similar approach. However, these actual 15-day average reported sleep onset times were about 5 minutes slower than reported on the napping questionnaire for each group (see Table 1).

In general, both appetitive and replacement nappers filled out the diaries in much the same way. Appetitive nappers tended to rate themselves as much sleepier in the morning than the replacement nappers ($t = 1.92$; $p < .001$). There were also very few differences between appetitive and replacement nappers.

Differences between Pre- and Post-Nap Diary Reports

Important differences between the responses of subjects on the sleep diary on the day they slept in the laboratory (and the preceding

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night) compared to the responses on the day (and night) after they slept in the laboratory are presented in Tables 9, 10, and 11. Comparisons with the 13-day baseline mean (excluding the pre- and post-nap nights) are also summarized. From these tables it is possible to draw some conclusions regarding the relative benefits or ill effects of the laboratory nap in the napper and non-napper groups, as well as to check on the degree to which the pre-nap diary was typical of the average diary responses.

Table 9 summarizes the descriptive parameters of sleep onset and length for the pre- and post-laboratory nights, compared to the average of the 13-day diary baseline. There are no major significant differences between groups. Some non-nappers had considerably more difficulty sleeping after the laboratory nap. That night they took an additional 11 minutes to fall asleep, and slept for about 25 minutes less than they typically did during the diary period. For both measures, the high degree of variability between subjects precluded statistical significance, but post-sleep variability in sleep onset time was much greater than the baseline average or the pre-nap mean ($p < .01$). It seems that the nap actively interfered with the night sleep of at least some non-nappers. Although the differences are smaller, the appetitive napper curtailed sleep both before and after the laboratory nap, but this was less apparent for replacement nappers. However, while the nap led the replacement napper to take longer than usual to fall asleep, the appetitive napper fell asleep more quickly after the nap. While

TABLE 9

Comparisons of Estimated Sleep Parameters for Appetitive (N = 10),
Replacement (N = 8), and Non-Nappers (N = 12) for Nights
Preceding and Following Laboratory Nap Compared to
Two-Week Sleep Diary

Sleep Diary Estimated Times	13-Day Avg			Pre-Lab Nap			Post-Lab Nap Baseline		
	N-N	App	Rep	N-N	App	Rep	N-N ^a	App	Rep
Time to bed last night	01:01	01:06	01:07	01:07	01:12	01:25	00:57	01:12	01:19
Time awake today	08:46	08:30	08:48	08:35	08:10	08:55	08:25	07:59	08:50
Hours slept last night	7:12	7:04	7:22	7:01	6:42	7:04	6:42	6:31	7:05
Minutes to fall asleep	29.2	18.7	19.7	27.7	16.5	26.3	40.5*	15.5	25.0

*Non-napper variance greater on Post-nap night than on Base 13 day or Pre-nap (e.g., $F = 8.82$, $p < .01$ for post-night compared to baseline variance of minutes to fall asleep respectively).

Note.--For any within group comparisons, differences between means are insignificant, although replacement nappers are more variable post-nap. Between group significance tests are not recorded on this table, though there are virtually no subgroup differences on any of these measures except for the greater variability of non-nappers, and replacement nappers to a smaller degree, compared to appetitive nappers.

^aThese data exclude 1 non-napper who did not sleep at all during the night after the laboratory nap. It is not clear whether this was related to the nap, or exclusively due to the following day's examinations. This subject's data for the remaining nights was quite typical of the rest of the group.

these differences are small and insignificant, they are consistent with data reported below comparing nap and no-nap days over the sleep diary period.

Table 10 summarizes some of the within-group differences that were found between pre- and post-laboratory naps concerning the quality of sleep and associated daytime activities. Appetitive nappers typically reported obtaining considerable subjective benefits from the nap, indicating that they slept even better than usual ($p < .01$), were less tired ($p < .05$), had less difficulty concentrating ($p < .05$), and were less ($p < .001$) sleepy "now" than usual (only about half of these 13 days involved napping). Replacement nappers also reported sleeping even better than usual ($p < .02$) and having little difficulty concentrating because of fatigue ($p < .01$). Thus, the nap had positive effects for both groups. In striking contrast, non-nappers slept significantly less well than usual ($p < .05$), more frequently took medication "during the preceding 12 hours" ($p < .01$ —while these were not usually sleeping medications, there was a significant incidence of aspirin-type preparations), tended to avoid their usual levels of physical activity ($p < .002$) and reported that, more than usual, they were too fatigued to concentrate ($p < .10$). Thus, the deleterious effects of the laboratory nap on sleep onset and length of sleep on the night after the nap may have been associated with some physical and mental impairment. This is, of course, why these non-nappers prefer not to nap in general.

TABLE 10

The Effects of Napping in the Laboratory on the Subsequent
 Night's Sleep Activity for Non-Nappers (N = 12) and
 Appetitive (N = 10) and Replacement (N = 8) Nappers

Sleep-Diary Variable	Night Pre-Lab Nap	Night Post-Lab Nap	13-Day Mean	Differences and p (two-tailed)
<u>Appetitive Nappers</u>				
Sleep well last night	1.00	1.00	.91	(Pre, Post) > Base; $p < .01$, $p < .01$
Fighting off sleep yesterday	.70	.30	.32	Pre > (Post, Base); $p < .05$, $p < .05$
Too tired to concentrate yesterday	.40	.10	.26	Pre > Post; $p < .05$
Take any naps yesterday	.60	.80	.54	Post > Base; $p < .10$
Could you sleep <u>now</u>	1.00	.60	.72	Pre > (Post, Base); $p < .05$, $p < .001$
<u>Replacement Nappers</u>				
Sleep well last night	.88	1.00	.91	Post > Base; $p < .02$
Unusual physical activity	.00	.13	.26	Base > Pre; $p < .01$
Too tired to concentrate yesterday	.50	.00	.24	(Base, Pre) > Post; $p < .05$, $p < .01$
Could you sleep <u>now</u>	1.00	.63	.66	Pre > (Post, Base); $p < .10$, $p < .01$
<u>Non-Nappers</u>				
Sleep well last night	.92	.64	.85	Pre > Post; $p < .05$
Hours sleep last night	7.01	6.14	7.20	Base > Post; $p < .001$
Medication last 12 hours	.00	.17	.08	(Post, Base) > Pre; $p < .20$, $p < .01$
Unusual physical activity yesterday	.33	.00	.14	(Pre, Base) > Post; $p < .05$, $p < .001$
Too tired to concentrate yesterday	.33	.42	.19	Post > Base; $p < .20$

Table 11 summarizes in more detail responses to the four questions which turned out to be the most significant in discriminating among the groups in terms of the effects of the laboratory nap. Non-nappers reported sleeping significantly less well as a consequence of napping in the laboratory than they had either on the preceding night or over the 13-day diary baseline ($\underline{t} = 2.02$; $p < .05$). There are no significant differences between pre- and post-nap responses for either of the napping groups. In fact, all of the nappers reported sleeping very well on the night after the nap, and this is typical of their sleep reports regardless of whether they napped or not during the preceding day.

The non-nappers sleep more poorly after the laboratory nap than they do on ordinary days when they do not nap, and they also sleep significantly more poorly after the nap than either the appetitive or replacement nappers ($\underline{t} = 2.71$; $p < .02$ for both appetitive and replacement nappers). Non-nappers also had more difficulty falling asleep the night after the nap than they either had on the night before the nap ($\underline{t} = 1.80$; $p < .10$), or during the 13-day diaries. Non-nappers also tended to awaken during the night more frequently than nappers following the laboratory nap ($\underline{t} = 2.26$; $p < .05$).

Although non-nappers generally took longer to fall asleep over the 13 days than nappers ($\underline{t} = 1.79$; $p < .10$), this difficulty is accentuated following the laboratory nap, particularly in comparison to the appetitive nappers ($\underline{t} = 1.94$; $p < .10$). Thus, the non-nappers have considerably more difficulty in falling asleep, and as a group are much more

TABLE 11

The Effects of Laboratory Napping on the Subsequent
Night's Sleep Compared to Typical Nights

Did you sleep well last night? (Yes, scored 1; No, scored 0)

Group	Non-Nappers	Appetitive	Replacement
Pre-Nap	.92	1.00	.88
Post-Nap	.64	1.00	1.00
13-Day Base	.85	.91	.91

About how long did it take you to fall asleep last night? (Answer = minutes)

Group	Non-Nappers	Appetitive	Replacement
Pre-Nap	25.6	13.20	28.10
Post-Nap	39.8	13.00	25.0
13-Day Base	26.7	16.9	19.1

How many hours did you sleep last night? (Hours: minutes)

Group	Non-Nappers	Appetitive	Replacement
Pre-Nap	7:01	6:42	7:04
Post-Nap	6:08	6:52	7:05
13-Day Base	7:12	7:04	7:21

At any time yesterday, were you ever so tired that you had difficulty concentrating on a task which you were trying to accomplish?

Group	Non-Nappers	Appetitive	Replacement
Pre-Nap	.33	.40	.50
Post-Nap	.42	.10	.00
13-Day Base	.19	.26	.24

variable in their ability to fall asleep at night compared to nappers ($F = 3.31$; $p < .05$)--they become even more variable on the night after their nap compared to other nights ($F = 6.83$; $p < .01$). It is also interesting to note that the replacement nappers took longer to fall asleep both before and after the nap compared to their 13-day average. While this tendency is not significant, their time to fall asleep is more variable for both of these nights compared to their typical performance ($F = 3.53$; $p < .05$ pre-nap; $F = 14.44$; $p < .001$ post-nap). This increased difficulty in falling asleep the night before the laboratory nap, together with the poorer than usual night's sleep may well have been a preparatory response in view of the demand that was made on them to sleep when they came to the lab.

Not only did the non-nappers tend to sleep poorly and take longer to fall asleep as a consequence of the nap, but they also slept for a shorter time on the night after the nap compared to the night before the nap, or their typical 13-day mean ($t = 1.42$; $p < .20$). While the reduction in sleep time is 53 minutes, it is only of borderline significance. However, again as a group they became significantly more variable following the nap ($F = 5.06$; $p < .01$), and much more variable than all other nappers ($p < .001$ in each instance). In marked contrast, the length of sleep of both the appetitive and replacement nappers did not differ either before or after the laboratory night compared to their 13-day average.

Not only did the laboratory nap have serious consequences for the non-napper on the following night, but the laboratory nap seemed

to have positive consequences for nappers. For example, in response to the question, "At any time yesterday were you ever so tired that you had difficulty in concentrating on a task which you were trying to accomplish?", both the appetitive and replacement nappers had significantly less concentration difficulty on the day following the nap compared to the day preceding it ($t = 2.08$; $p < .10$ and $t = 2.83$; $p < .02$, respectively). In contrast, there was a tendency for the non-napper to have more difficulty concentrating on the laboratory nap day than on all other occasions ($t = 1.81$; $p < .10$).

Other isolated differences between the groups were consistent with these findings. For example, the nappers came to the laboratory prepared to nap. In response to the question "Could you fall asleep now?", all of the nappers responded "Yes," compared to only half of the non-nappers ($t = 3.39$; $p < .002$). Thus, it seems the nappers have a great deal more confidence in their ability to take a nap on command than the non-nappers.

In general, it can be concluded that napping has a deleterious effect on at least some of the habitual non-nappers, interfering with their ability to fall asleep, the length of time they sleep, and the feeling of having slept well on the following night. On the other hand, nappers seemed to achieve some benefit from napping in terms of their own estimated ability to function appropriately in relationship to the nap.

The differences between appetitive and replacement nappers were relatively minor in terms of the consequences of the laboratory nap

compared to other occasions. However, it would be difficult for such differences to show up in this kind of analysis. Nappers tended to nap on one day out of every two while they completed the diaries. The consequences of napping during the laboratory time would presumably be no different from their napping on other occasions; therefore, it would be predicted that the 13-day average response would be like the typical response to any one day on which a napper napped, and just as typical of the days in which he did not nap.¹³

The Parameters of Napping--15-Day Sleep Diary

The basic parametric information about frequency and length of napping, as well as information concerning the total amount of sleep per nap, per night, and per 24 hours are presented in Table 12 for each of the subgroups. These data have been adjusted to eliminate the effects of the laboratory nap; thus, the total sleep time data is presented for 13 days to eliminate the effects of the night before and after the laboratory nap, as well as the laboratory nap itself.

Nap Frequency. The appetitive nappers answered the question "Did you take a nap yesterday?" significantly more often than the replacement nappers. Appetitive nappers took naps on an average of 52 percent of the 13 days compared to replacement nappers who napped on 40 percent of the days ($t = 1.56$; $p < .20$). The two napping groups differed in the frequency of naps from non-nappers who napped only on 5 percent of the

TABLE 12

Parametric Data (13-Day Diary) for Napping and Nighttime Sleep

Variable	Non- Nappers N=12	Nappers		F
		Appetitive N=11	Replacement N=9	
<u>Nap Parameters</u>				
Frequency (13-day)	.67	6.73	5.11	1.39 ^a
Length (minutes)	68.00	62.4	74.4	.30
Time began (p.m.)	4:35	4:09	3:57	--
Percent of 24 hour sleep	.69	7.27	5.69	--
<u>\bar{X} Night Sleep (Hrs:Mins.)</u>				
Hours sleep: questionnaire	7:14	7:49	7:38	2.25
Hours sleep: 13 night avg.	7:21	7:20	7:32	.99
Hours sleep: 24 hour avg.	7:25	7:54	8:00	2.63 [*]
Hours sleep: 24 hour variab.	:41	:57	:31	3.38 ^a
<u>13-Day Totals (Hrs:Mins.)</u>				
Night Sleep	95:36	95:24	98:02	.99
Nap Sleep	:40	7:30	5:55	10.40 [*]
Total Sleep	96:16	102:54	103:57	2.02 [*]

* $p < .05$ ** $p < .01$ ^aThis excludes non-napper group.

days ($p < .00001$) in each case. During the 13 days appetitive nappers took a mean of 6.7 naps and replacement nappers a mean of 5.1 naps.

Only one of the nappers failed to nap at least twice during the 13 days (equivalent to the minimum requirements for a consistent napper). Nine of them napped every day, but 7 of the 11 appetitive nappers, and only 1 of the 12 replacement nappers napped 7 or more times ($p < .02$). Among the 12 non-nappers, a total of 7 naps occurred over the 13 days. One subject napped three times, although this was inconsistent with the criteria for non-nappers over longer time periods, 4 other subjects took one nap each during the two weeks.

Nap Time and Length. During the 13 days the two napper groups began their nap at about the same time. Appetitive nappers typically napped at 4:09 p.m.; replacement nappers at 3:57 p.m. The standard deviation of the time the nap commenced was almost exactly one hour for the appetitive and replacement subgroups. Well over half of the 83 naps taken by the 11 appetitive and the 55 naps taken by the 8 replacement napper occurred between 2 p.m. and 5 p.m. (58 percent and 51 percent, respectively). Only 3 of the 138 naps recorded by both groups of nappers occurred after 8 p.m. The distributions of naps for morning (6 a.m. to 2 p.m.), early afternoon (2 p.m. to 5 p.m.) and early evening (5 p.m. to 8 p.m.) did not differ between the groups. For appetitive and replacement nappers, the length of the nap tended to get shorter as the day progressed. Naps before 2 p.m. lasted on the average 104 and 80

minutes; from 2 p.m. to 5 p.m., 56 and 75 minutes; and only 50 and 32 minutes respectively between 5 p.m. and 8 p.m.

Napping and Total Diary Sleep Time. In the napping questionnaire, it was reported that the three groups did not differ markedly in the amount of sleep they regularly obtained at night. On the sleep diary subjects were asked to indicate the time they went to sleep and the time they woke up, as well as the length of sleep each night during the 2-week period. It is clear from Table 12 that the mean actual reported amount of sleep and the more general estimate of sleep length in the questionnaire agree surprisingly closely, varying by 7 minutes or less for replacement nappers and non-nappers. However, the appetitive nappers obtained 29 minutes less sleep each night than they actually reported regularly receiving, but this difference was not significant ($t = 1.02$).

This basic information does not really tell us whether the total amount of sleep these subjects obtained in any one day is different because it ignores the time they spent napping. When mean daily nap length is added to mean nightly sleep length, a slightly different picture emerges. While non-nappers obtain about 7 hours and 25 minutes of sleep per night, the appetitive and replacement nappers obtain about 8 hours ($F = 2.02$; $df = 2, 29$; $p < .10$). The appetitive napper is much more variable than any of the other subjects in his total sleep time ($F = 3.81$; $p < .05$).

These same data are presented in a different way in the bottom part of Table 12, where the total number of hours of sleep actually obtained during the 13-day period, with and without naps, is tabulated. In fact, of the total sleep obtained over 13 days, the appetitive nappers obtain 7.3 percent of this by napping compared to 5.7 percent for the replacement nappers, while the non-nappers get less than .6 percent of their sleep through napping.

To our knowledge, this is the first study that has looked at the extent of napping in terms of one's total sleep time per day or over a period of time. While the proportion of time spent napping even for these frequent nappers is low relative to the amount of sleep obtained at night, it is particularly striking that it remains a sleep segment that is important out of proportion to the time spent, both in terms of subjective satisfaction and, as we have shown elsewhere, in terms of its recuperative value.

The Conditions for and Consequences of Napping

One of the primary reasons for conducting the sleep diary survey was to investigate the effects of napping on sleep satisfaction and sleep parameters. One tactic would, of course, involve having subjects sleep overnight in a sleep laboratory on days on which he did or did not nap. This is an appropriate but expensive procedure, and would not necessarily answer many of the questions involving sleep satisfaction variables which we feel are central to an understanding of napping behavior and sleep

efficiency. Consequently, the home sleep diary was selected as an important source of preliminary information.

Two questions have concerned us so far. First, what are the conditions that occur during a 24-hour period, particularly in terms of nighttime sleep parameters, that are associated with a decision to nap or not to nap? Second, what are the consequences of napping, compared to not napping, on the subsequent 24-hour activity, particularly the night's sleep after a nap, and also in terms of the reasons for napping? While we would predict that the parameters of sleep on the nights preceding and subsequent to the nap have little effect on the occurrence of napping in the appetitive group, we would predict that the duration and quality of a night's sleep is crucial to the likelihood of napping for the replacement napper.

These analyses are complex, and are incomplete. Three strategies of approach to the question have been initiated, and can be illustrated.

Frequency of Napping. Multiple contingency χ^2 analyses have been conducted on the frequency of napping and non-napping in relationship to the different subgroups and some parameters of sleep on preceding and subsequent night sleep. This is illustrated in Table 13. This table analyzes the frequency of napping as a conjoint function of three variables: (a) appetitive versus replacement napper types, (b) whether or not a nap was actually taken on a particular target day, and

TABLE 13

Relationship Between Length of Sleep on the Preceding Night and the Likelihood of Napping on Subsequent Day in Appetitive and Replacement Nappers (N = 13 Night-Nap Day Combinations, Summed Over Subjects for the Four Contingency Possibilities: Night Sleep Dichotomized at Subject's Own Mean over 13 Diary Days).

	Last night's sleep time compared to 13-day average		N	χ^2	p <
	Shorter	Longer			
<u>10 Appetitive Nappers:</u>					
Took nap	35	40	75	.25	.60
No Nap Taken	31	28	59		
<u>9 Replacement Nappers:</u>					
Took Nap	29	17	46	4.07	< .025
No Nap Taken	28	41	69		

Source	χ^2	df	p <
Total	12.11	4	.01
App-Rep vs Short-Long	.01	1	ns
App-Rep vs Nap-No Nap	5.69	1	.01
Short-Long vs Nap-No Nap	.89	1	ns
Interaction (3-way)	5.52	1	.01

(c) whether or not the previous night's length of sleep was shorter than or longer than each subject's own 13-day average. The data tabulated is the frequency of napping, or not napping, as a function of the two groups, and either long or short previous night's sleep.

A multiple contingency χ^2 was calculated on this data and is summarized in the table. The total χ^2 of 12.11 is significant ($p < .01$). However, the data can be meaningfully interpreted only in terms of the interactions within the partialled-out main effects summarized in the table. There is no difference in the frequency of short and long sleep length on the previous night between appetitive and replacement nappers (primarily because of the way the data was dichotomized). There is also no overall difference between the occurrence of napping or non-napping as a function of a short or long sleep on the previous night, but this result obscures the important significant interaction ($\chi^2 = 5.52$; $p < .01$) which suggests that the effect of previous sleep length on the subsequent occurrence of napping differs for the kind of napper. Even though the appetitive napper takes more naps in 13 days than the replacement napper ($\chi^2 = 5.69$; $p < .01$), whether or not he naps bears no relationship to the length of his sleep the previous night ($\chi^2 = 0.25$; $p < .60$). However, for the replacement napper there is a strong tendency for him not to nap if he had a longer than average night's sleep the previous night ($\chi^2 = 4.07$; $p < .025$). In fact, if he had a long night's sleep the previous night, he is only about one-third as likely to nap the following day than if he had a short night's sleep. Similarly, there is a tendency for him to be more

likely to take a nap if he had a short night's sleep the previous night.

While this particular finding is important in its own right, and is consistent with our definition of appetitive and replacement napping, this also illustrates a powerful methodology for analyzing the relationship between the likelihood of napping and various objective and subjective parameters of the previous night's sleep and following night's sleep in relationship to the nap, and the differences that occur between the groups being studied. There are limitations to this approach, however: napping frequency is summed over all days for all subjects, and it is possible that for some comparisons one subject with an extremely high incidence of napping or aberrant sleep patterns could unduly influence the results.

Napping and the Preceding and Subsequent Night's Sleep. The 2-week sleep diaries were divided for each subject into days on which a nap was taken and days on which no nap was taken. Several diary variables concerning quality and parameters of sleep were analyzed in terms of those days on which naps were and were not taken. Nap day and no-nap day values were averaged across each subject, and the resulting means for each subject were then averaged over all subjects in both napping groups. This method of analysis averages across subjects within the groups, and therefore cannot be unduly influenced by typical subjects or more frequent nappers. So far, this approach has clarified our distinction between the different types of nappers.

Appetitive nappers took longer to fall asleep the night following the daytime nap ($t = 1.77$; $p < .10$). They slept 41 minutes less on nights they took a nap compared to nights when they did not nap ($p < .20$). However, they slept more soundly following a nap and awakened during the night significantly less often ($t = 2.18$; $p < .05$). In contrast, there were no differences between the night before they took the nap and the corresponding nights preceding non-nap days on any of these variables. Thus, as predicted, a particular night's sleep activity for appetitive nappers is not related to whether or not the subject naps the next day.

A different picture emerges for the replacement napper. While the appetitive napper takes an extra 6 1/2 minutes to fall asleep after a nap, the replacement napper instead goes to bed an hour later ($t = 1.54$; $p < .20$) but does not subjectively report having any specific difficulty in falling asleep after a nap. On the day when he takes a nap, the replacement napper gets up in the morning about 46 minutes earlier than on days when he does not nap. He also slept 47 minutes less on the night before he naps than on nights when he does not take a nap ($t = 2.10$; $p < .05$). In addition, he sleeps less well during the night if he has not taken a nap the previous day ($t = 2.23$; $p < .05$). Thus, the sleep diary confirms our original hypothesis that the replacement napper, unlike the appetitive napper, naps in order to make up for lost sleep time. It appears that he may well lose this sleep in the morning rather than by going to bed late the previous night. However, this in turn may be partly a reaction to his having slept less well.

Thus, these results indicate that appetitive napping is unrelated to the sleep characteristics of the surrounding night, replacement napping occurs in response to an abbreviated previous night's sleep, though the shorter sleep length may be a function of earlier morning arousal.

Nap Characteristics and Sleep Onset and Duration

A third approach to the examination of the determinants and consequences of napping is to examine the surrounding 24-hours' activities, particularly pre- and post-nap sleep parameters, as a direct function of nap characteristics, either in terms of satisfaction or parametric features. As an example of this approach we examined sleep onset and sleep length, both for the night before and the night after the nap, as a function of the length of the nap itself. Is a short nap different in function to a long nap? One possibility is that a short nap may have more of the characteristics of a nap which is either involuntary and accidental, or at least of a feeling that sleep is so imminent and overwhelming that it cannot be avoided or delayed.

This question was investigated by dichotomizing nap length at the subject's own mean nap length, and examining sleep onset and duration of both preceding and subsequent night's sleep. The results are reported in Table 14. Parenthetically, it was noted that the mean time during the day that replacement subjects took either a short or a long nap did not vary more than 2 minutes, but appetitive nappers commenced their short naps 37 minutes earlier in the day than their longer naps.

TABLE 14
 Sleep Onset and Length on Night Before
 or After Either a Long or a Short Nap

Group	N	Night Preceding		Night Following	
		Short Nap	Long Nap	Short Nap	Long Nap
<u>Time to sleep (mins)</u>					
Appetitive	11	20.7	17.3	21.0	17.2
Replacement	8	19.3	19.2	18.0	13.9
<u>Sleep length (hrs.: mins)</u>					
Appetitive	11	6:55	8:00 [*]	6:49	7:08
Replacement	8	8:01	7:17 ^{**}	8:03	7:20

* $p < .05$

** $p < .01$

As the long naps started on the average about 10 minutes earlier than all of the naps of the replacement napper, it is possible that the appetitive subject has two qualitatively different kinds of nap: a short one which is primarily for pleasure or psychodynamic reasons and a longer one that is combined with sleep replacement functions. The appetitive napper was picked primarily for his psychological need of napping, but this did not preclude some occasional replacement napping, (although there were not any strong appetitive overtones allowed in the replacement napper criterion).

While this hypothesis has merit, if anything the data for appetitive nappers suggests the short nap has more of the qualities of the replacement nap. On the day preceding the nap, replacement nappers who had taken a long nap had significantly less sleep the night before (compared to their short naps, $p < .01$). However, for the appetitive napper it is the short nap that is preceded by a shorter than usual sleep the previous night ($p < .05$). Although the appetitive napper is not differentially affected by a long or short nap on the following night (even though, as we indicated above, he does sleep a little less after he naps) the replacement napper reduces his post-nap sleep time by virtue of having taken a long rather than a short nap ($p < .05$). Interestingly, the appetitive napper gets more sleep both before and after a long nap than he does before or after a short nap, again indicating that sleeping habits are largely independent of his napping: perhaps his longer naps are more dependent on such variables as whether he can spare the time.

5. COLLABORATIVE STUDY: RECOVERY FROM FATIGUE DURING PROLONGED CONTINUOUS PERFORMANCE

Our central interest has been the recuperative effects of sleep on human performance and the restorative value of short sleep periods as a means of recovering from fatigue. Our previous studies have been concerned with the development of appropriate tasks to measure recovery functions after relatively short periods of sleep loss. While these prior results have been encouraging, they have been limited because of the relatively short time in which subjects have been studied in the special context of the experimental laboratory. Our conclusions about these measures must, of necessity, be limited because it is clear that such factors as circadian rhythms and motivation are potent factors that modify human performance. Such factors could easily serve to obscure important effects during short-term performance following moderate levels of sleep deprivation.

We were, therefore, particularly fortunate to be able to include our previously developed tasks in an ongoing study on performance during continuously monitored long-term work-rest activity periods at the Performance Research Laboratory founded by Dr. Earl Alluisi and currently directed by Dr. Morgan and Dr. Baker. Before describing this collaborative study, the results of which are still being analyzed, some appropriate background is necessary.

Performance Consequences of Fatigue

A number of previous studies have documented the deleterious effects of sleep deprivation on performance (e.g., Naitoh, 1969). The focus of such studies has been on the progressive deterioration of functioning as the individual is required to remain awake for longer and longer periods. We have sought to approach the question of how short periods of sleep may reduce fatigue by investigating the recovery function in relation to performance. Such an approach obviates the need for continuous monitoring during sleep deprivation, permitting us to place more emphasis on the physiological nature of the sleep period in relation to its possible beneficial effects on performance. Our strategy so far has been to bring subjects to the laboratory while fatigued, to see how their performance benefits from short periods of sleep.

Much of our concern has focused on the development of appropriate performance measures. Most investigators have concluded that individuals who have been sleep-deprived even for considerable periods are able to marshal their resources sufficiently to perform for short periods of time at a level close to their normal undeprived performance. The most successful attempts to document the effects of sleep deprivation have involved either very long periods with no sleep (Williams, Lubin, & Goodnow, 1959), or lengthy performance tasks such as those typically encountered in a work situation (Alluisi, 1969), or by the use of a continuous vigilance situation (Wilkinson, 1968). Despite the fact that even moderate sleep deprivation has clear and unambiguous subjective consequences for the individual,

decrements induced by moderate deprivation on short-term performance have been difficult to document.

An encouraging exception was the study by Williams, Lubin, and Goodnow (1959), who were able to demonstrate that subjects deprived of sleep for only 26 hours show a performance decrement when faced with a task requiring the short-term maintenance of attention and motivation. This held if the task was sufficiently demanding in terms of cognitive ability. Performance on such a task does not break down completely but tends to become sporadic, with the most powerful dependent variable being the omission of items. In view of such studies we felt it might be possible to document performance effects in the laboratory which parallel the subjective effect of sleep deprivation even when the amount of sleep loss is relatively small. The appropriate task would require: (a) a strong cognitive load (Williams et al., 1959); (b) experimenter pacing (Naitoh, 1969); (c) little feedback to the subject concerning the adequacy of his own performance, thereby making it difficult for him to accurately allocate his resources when fatigued. Two such tasks have been developed which have produced encouraging initial results.

Descending Subtraction Task. We have reported that when moderately sleep-deprived subjects were required to perform the Descending Subtraction Task performance improved following brief naps. The descending subtraction test requires the subject to keep in mind and manipulate several items of information simultaneously,

and meets the first of the criteria listed above by providing a strong cognitive load.

In this task, the subject is given a 3 digit number, e.g. 563, and is asked to serially subtract 9, then 8, then 7, etc., from the previous progressive total, saying each successive total aloud. After subtracting 2, he begins a new cycle by continuing to subtract 9, etc. In order to accomplish the task successfully, the subject must keep in mind the particular number he has just said, as well as the number he needs to subtract, both numbers being altered with each successive subtraction, as fast as possible. Three major error categories are losing track of the original number, errors in subtraction, or errors in the choice of number to subtract. Thus, the task allows the assessment of both speed and accuracy.

Typically, subjects who are alert and rested yield reasonably stable and reliable performances on the task and have relatively little difficulty carrying it out when they are fully focusing their attention on it--a situation that does not obtain with fatigue or immediately on arousal from sound sleep. The task has proven useful as a measure of performance prior to sleep, during sleep and after sleep. We have found that subjects who are tired, or who are awakened from sound sleep, encounter considerable difficulty with this task. We have demonstrated significant performance decrements immediately after being awakened from sleep, when compared to baseline performance before sleep, and subsequent performance increments when assessed 15 minutes after being fully awake. A highly promising aspect of our data is the finding that

short-term sleep, or napping, results in significant performance increments once the subject is fully awake.

Randomization. The Random Number Generation task has been derived from our work on the measurement of the monitoring and deployment of human attention. The subject is asked to produce numbers between 1 and 10 at random in time with a metronome. The task is not a usual or even an especially easy one for subjects to perform. It is the antithesis of what we are taught to do as we develop--to become organized and predictable in our behavior, and especially in our patterns of thought. Success at the task would seem to require just the reverse--the controlled non-patterning of thought. Though this task sounds simple, it demands that the subject keep in mind the numbers he has generated in the past--in order to avoid using any given number more than another, or repeating a number too frequently. Research reviewed by Wagenaar (1972) has shown that the random number task has the potential of reflecting alterations in consciousness, but the current available methods of analyzing randomness in humans were insensitive, and required subjects to produce a large number of digits for analysis. Our laboratory has developed a technique for determining randomness adapted from Tulving's (1962) work on the organizational strategies of free recall, and developed a computer program for scoring the randomness of the subject's output with as few as 100 digits in order to make this a practical procedure. Another important aspect of this task is that it is well nigh impossible

for either the subject or the experimenter to detect the relative changes in randomness which occur. Thus, within a broad range of performance there is no feedback to the subject concerning how well he is doing. Finally, it is possible to pace this procedure externally by insisting that subjects produce a number each second in time with a metronome.

Pilot studies had indicated that the randomization task was relatively insensitive when subject-paced; it varied with sleep deprivation when experimenter-paced. We wished to add an additional cognitive load to the performance on the random number task. After experimenting with a variety of procedures, we selected a two-hand coordination task which subjects can learn to perform with no errors even when fatigued. Subjects were trained to the asymptote criterion of repeated errorless performance and were then required to generate random numbers while simultaneously maintaining perfect performance on the two-hand coordinator. The background task of maintaining such performance on the motor task requires continuous monitoring by the subject, and apparently serves to make the random number task a far more sensitive measure of cognitive capability. We hypothesized that when an individual is fatigued, more of his resources would be involved in maintaining perfect performance on the motor skill, and thus less would be available for the generation of random numbers. This hypothesis derived support when subjects were asked to generate random numbers while learning to perform the two-hand coordination task (Graham & Evans, 1973). Randomness was depressed, compared to baseline, when subjects first began to learn the two-hand

coordinator task. However, as learning proceeded, the motor performance improved and randomness increased. When the coordination task had been learned so well that it could be performed automatically and with no real effort, random number generation returned to baseline. Thus, the randomization task appears to measure the amount of attention involved in the learning of a joint task.

The results reported by Williams and Lubin (1967) and of Graham and Evans (1973) in conjunction with a series of pilot studies reported last year suggested that the combination of the two-hand coordinator and random number generation might well provide the kind of intellectual challenge which exceeds the capabilities of the fatigued individual in the sense that he performs less than optimally even when motivated to maintain performance. Thus, the ability to maintain randomness while simultaneously maintaining asymptote on a performance task, and the descending subtraction task were deemed sufficiently promising that they were included as appropriate tasks in the collaborative study involving continuous performance during prolonged fatigue.

Sustained Performance Research

The programmatic research being conducted by Alluisi, Morgan and their colleagues is concerned with the conditions under which continuous work loads can be maintained efficiently over long time periods, sometimes with minimal rest. This research has been based on the

synthetic work methodology, which has been described by Morgan and Alluisi (pp. 843-844, 1972).

The contribution of the synthetic-work methodology to the assessment of human performance is unique in that the tasks of the battery are combined--with use of the 2-hr. time-sharing task schedule--into a synthetic-work or job situation that is typically S's responsibility over periods of work-day duration (e.g., 8 hr.) on each of 12 to 15 successive days. The performances typically measured with this battery are within the domain of work behavior; they differ in predictable ways from the test-behavior performances more frequently studied (cf. Alluisi, 1969, pp. 59-60). That is to say, Ss approach a job with motivational, attitudinal, and energy states that are characteristically different from their approach to specific, relatively simple, short-term test situations. With a suitable job such as that provided with the present battery in the synthetic-work situation, work behavior may be studied in the laboratory with many (if not all) of the usual controls. This provides a more valid basis for the generalization of results to man's work behavior

They summarized the results of their first decade of research on sustained performance, work-rest scheduling and circadian rhythms as follows (Morgan and Alluisi, 1972). (a) Man can probably follow a 4-hour work, 4-hour rest schedule for very long periods without detriment to his performance. (b) For shorter periods of 2 or possibly 4 weeks, a more demanding 4-2 hour work-rest schedule can be followed with reasonable maintenance of performance efficiency. (c) Man uses up his performance reserves in following the more demanding schedule, and so is less able to meet the demands of emergency conditions such as those imposed by sleep loss. (d) The circadian rhythm that is evidenced in physiological measures may also be evidenced in performance measures: the cycling may be demonstrated

in the performances of overloaded operators depending on several specific factors. (e) The tasks in the battery and the methodology employed in the synthetic-work approach yield measures that are sensitive to the manipulation of both obvious and subtle experimental variables.

The study being conducted was the sixth in a series of studies dealing with the effects of continuous work and sleep loss on performance. It is referred to as SPADE 6 by Dr. Morgan's laboratory. Its aims were to examine the ability of subjects to maintain performance during 36 hours of continuous work, the extent to which four hours of sleep is adequate for restoring performance to its baseline level, and the interaction of sleep loss and continuous work with the underlying diurnal rhythm. This particular study completed a parametric investigation of the interaction of diurnal-cycling and continuous work, and data was to be available for six crews of subjects, each of which began working a 36-hour period after continuously working for 4-hour intervals throughout the 24-hour day.

Procedure¹⁴

Subjects. Paid student volunteers were solicited and then assigned to either one of two possible five-man crews for the duration of the study (the ABLE crew and the BAKER crew). Assignment was on the basis of academic scheduling commitments. Each crew received an orientation to the study in an initial briefing session. At this time they were also introduced to the particular tasks they would be required to

perform during the course of the experiment. The subjects were located simultaneously in five individual but adjacent cubicles, comfortably seated before their individual test panels. They could hear each other but had no visual contact.

Multiple-Task-Performance Battery. The six separate tasks which comprise the Multiple-Task-Performance Battery (MTPB) are presented by means of a small, compact panel placed on the tables in front of individual subjects. The tasks attempt to provide measures of general performance functions applicable to a wide variety of specific work situations. The various measures each reflect some of several relevant dimensions: attentive and vigilance functions, memory and the reception--transmission of information, sensory-perceptual and sensory-motor performance, and interpersonal coordination, cooperation and organization.

More specifically, the individual is required to perform six activities: (1) Monitor and correct the status of several stimulus lights on the extreme left of the panel; (2) Monitor and correct the rate-of-change of stimuli at the extreme right of the panel; (3) Detect and correct bias-deviations in the continuous movement of pointers located in four semicircular scales placed in the upper central portion of the panel; (4) Perform arithmetic computations by subtracting the third of three sets of three-digit numbers from the sum of the first two sets, presented visually in the bottom central portion of the panel, indicating the answer manually; (5) Work on a target identification task presented visually in

the center of the panel; (c) Work in coordination with other team members in obtaining the solution to a randomly presented code-breaking problem, usually located in the central right portion of the panel.

The subject is responsible for the three monitoring task (1-3) on a continuous basis, but performs the other tasks only part of the time. The work-demand schedule may be low, intermediate or high depending on whether the subject is responsible for three, four or more tasks simultaneously. Thus, in a typical two-hour period, the subject is responsible for 30 minutes of low level activity, 60 minutes of intermediate activity and 30 minutes of high activity in a non-sequential order.

Collaborative Sleep Study Procedures

The collaborative study was initiated for the purpose of providing further information on possible performance alterations resulting from continuous work and long-term sleep loss as well as examining the potentially beneficial effects arising from subsequent recovery from that sleep loss.

Descending Subtraction Task. The subject is given a predetermined three-digit number and required to sequentially subtract from it the numbers from nine to two. He is to say aloud the answer derived from each subtraction. Upon subtracting the final number two, he then begins the sequential subtractions again from the number nine. He continues in this fashion, performing mental subtractions and saying the answers aloud,

for a period of three minutes. A typical correct sequence would be 8, 5, 816, 808, 901, 794, 790, 786, 783, 781, 772, 764, etc. The subject's responses are analyzed in terms of the mean time per response and percent of errors made in the three-minute task period.

Random Number Generation Task. The subject is asked to verbally generate a series of random digits using the numbers from one to ten inclusive. He says numbers aloud, in time with a metronome beating at the rate of one per second, for 105 seconds. Analysis is in terms of the S.O. (subjective organization) index described above, which expresses a function of the frequency with which any number follows any other number compared to chance expectations.

Two-Hand Coordination Task. This task has been extensively described by Melton (1947) and is one of the original Army Air Force tasks used in the selection of aircraft personnel. The subject attempts to keep a contact atop a target moving in an irregular circular pattern by turning two hand-crankes simultaneously. One crank moves the contact in a back or forward motion, the other at right angles from side to side. By moving the two handles at appropriate times, speeds and revolution distances, the contact can be made to move in any direction and appropriate speed in a 360° range. Analysis is in terms of time-on-target during the 120 seconds it takes the target to make two complete revolutions.

The coordination task is presented to the subject either separately or in combination with the randomization task, as described below. In the combined condition, the subject performs the coordination task and simultaneously attempts to generate aloud a series of random digits. In the separate condition, the subject performs each task alone. Performance on the motor task was of no immediate interest other than providing a simultaneous over-learned task to provide additional cognitive load during the randomization task.

The Collaborative Experiment: Procedure and Method

The experimental design of the study can be conveniently divided into four phases: (1) training, (2) interspersed-work-rest period, (3) continuous (36-hour) work and (4) recovery period interspersed-work-rest.

Training Procedures. During the month of November, 1973, all subjects received baseline training on the multiple-task-performance battery and also on the performance of the randomization and descending subtraction tasks. On the first day of training, subjects performed the descending subtraction, then the randomization task alone, and finally, the combined randomization-two-hand coordination task. They then continued training, alternating between performance of the motor coordination task alone and performance of the combined random number-coordination task. On day 1, each subject performed 13 two-minute coordination trials interspersed with 7 two-minute combined randomization-coordination trials.

The final tasks of the session involved performing the descending subtraction and random number tasks alone. Training continued on day 2, and thereafter, until each subject attained criterion on the combined task. The criterion established was a demonstrated ability to remain on target for 115 of the 120 seconds for four successive combined trials. This was, as it turned out, an unfortunate modification of our earlier procedures. We had previously insisted on asymptoted performance as perfect 120-second error-free trials only. The liberalization of the criterion was made in part because of the difficulty of achieving the more stringent criterion with this sample.

The subtraction and randomization performance data were recorded both manually and by a tape-recorder. Time-on-target was manually recorded from the clock attached to the two-hand coordinator apparatus.

Interspersed Work-Rest. The BAKER crew entered this phase of the experiment beginning at 4 a.m. on January 1, 1974. For the next 48 hours they operated the multiple-task-performance battery panel on a 4-4-4-12 alternating work and rest schedule. This provided each subject with 16 hours of work experience and 32 hours of rest during this phase of the study. The ABLE crew entered this phase of the experiment at 4 p.m. on January 7, 1974 and they were treated the same way except for the 12-hour clock-time displacement for each subject.

Continuous (36-Hour) Work. At 4 a.m. on January 3, 1974 the BAKER crew began the continuous work phase of the experiment. This entailed working continuously over the next 36 hours. Subjects performed at low (25%), intermediate (50%) and high (75%) levels of activity per 2-hour period throughout the 36-hour period. The ABLE crew entered this phase at 4 p.m. on January 9, 1974. Short food breaks were provided periodically during the low activity cycles.

Recovery Period Interspersed-Work-Rest. At the conclusion of the 36 hours of continuous work the subjects were allowed to sleep for a period of 4 hours. They then began another period of 48 hours during which they alternated work and rest on a 4-4-4-12 alternating work-rest cycle. The BAKER crew entered this phase at 8 p.m. on January 4, 1974 and the ABLE crew at 8 a.m. on January 11, 1974.

The experiment was concluded at 8 p.m. on January 12, 1974.

Experimental Procedures. Beginning with the interspersed-work-rest phase of the experiment, subjects performed the above tasks during the low level activity portions of the major experiment. The apparatus was installed in a separate room, and during the last 15-minute period of low level activity and the following first 15-minute low level activity period of the next two-hour period subjects discontinued their test battery activities and performed the collaborative tasks. In the predetermined sequence of Alpha, Bravo, Charlie, Delta and Echo--designations of

individual team member positions--subjects entered the experimental room and initially performed two two-minute combined coordination-randomization trials. Then they went to a different room for the separate tasks. Here they turned on the tape-recorder, received the descending subtraction starting number and performed the subtraction task for three minutes and the random number task for two minutes. Following this they returned to the continuous work battery room to continue with the main experiment. This sequence of events continued for the 48 hours of the interspersed-work-rest phase of the experiment. In all, subjects performed the combined task a total of 12 times, the subtraction task a total of 6 times, and the random number task a total of 6 times. The exception to the above sequence involved waking subjects from sleep on two separate occasions to perform the tasks. These data are included in the above totals.

During the continuous work phase of the experiment, subjects continued with the same task performance during low level activity periods. In all, each subject performed 10 combined performance-randomization trials, 5 subtraction trials, and 5 random number trials during the 36-hour continuous work phase of the experiment.

Following the continuous work phase subjects slept for a total of four hours. Immediately upon awakening, they entered the recovery period portion of the study. During this phase each performed 12 combined motor-randomization trials, 6 subtraction trials and 6 random number trials. The procedure is outlined schematically in Table 15, and the main results for a 24-hour period are summarized.

TABLE 15

Outline of Collaborative Sleep Study and Summary of Results on
Descending Subtraction and Random Number Tasks

Period	Trial	Time test done		Length prev. rest	Time since rest	DST		RNG (during THC) ^a
		Able	Baker			Time per Number	Percent errors	
Training	1	1800	0600	(8)	2	3.60	21.7	.379
	2	0200	1400	4	2	3.45	18.0	.364
	3	1000	2200	6	0	3.55	16.3	.363
	4	1800	0600	12	2	3.60	17.0	.352
	5	0200	1400	4	2	3.40	17.5	.387
	6	1000	2200	6	0	3.30	16.4	.347
Deprivation	7	1800	0600		2	3.00	16.5	.365
	8	0200	1400		10	3.20	14.8	.349
	9	1000	2200		18	3.10	15.9	.346
	10	1800	0600		26	3.30	15.9	.346
	11	0200	1400		34	3.85	15.3	.389
Recovery	12	0800	2000	4	0	4.15	18.7	.334
	13	1200	2400	4	4	3.15	15.2	.354
	14	1800	0600	4	2	3.20	17.3	.374
	15	0800	2000	12	0	3.35	16.7	.341
	16	1200	2400	12	4	2.85	14.2	.251
	17	1800	0600	4	2	2.90	11.4	.367

^aThe RNG and THC combined task has been completed to asymptote performance on THC of 4 consecutive errorless trials (115 out of 120 seconds trial length) prior to the phase of study.

Descending Subtraction Task

Data Analysis. Each time the descending subtraction task was performed, the subject's responses were recorded on an appropriate data sheet (and also on audio tape). The forms, together with the tapes, were sent to the Unit for Experimental Psychiatry, where all data analysis for the task was carried out.

Two research assistants independently listened to the tapes, and recorded the subject's responses. The data sheets were then compared, and any disagreements rescored. Again independently, the assistants played the tapes a second time, recording the length of time required for each subject to repeat the starting number, the length of time required to produce each block of 8 responses, and the point at which the 3 minutes allotted to the task was completed. They then examined the data sheet for each repetition of the task for errors, and classified those errors.

Data sheets were then turned over to a third assistant, who compared the two data sheets for each task performance and, in case of disagreement, requested that the data be rescored. All rescoring was done without reference to the original scoring. Where disagreement as to error classification occurred, the third scorer made the final decision.

Several dependent variables were derived from the data sheets: mean time to produce each number, number of errors, percent errors, time to repeat the starting number, items produced before the first error, and frequency of various types of errors. Of these, mean time per number

and percent errors were the most useful measures. The results reported below are based only on these scores.

To reduce the variance associated with individual differences in arithmetical ability, the mean and standard deviation of all trials for each individual subject were computed; raw data were then converted to standard scores with mean of 50 and standard deviation of 10. Subsequent analyses were based upon these standard scores. Results for mean time per number and mean percent errors are summarized in Figure 3 for each of the various experimental conditions. Data for both subgroups are presented in Table 15.

Mean Time per Number

Training Period. No significant differences between the crews were found during the training period (raw data) although the ABLE crew improved more over the two days than did the BAKER crew ($F = 6.28$; $df = 1,8$; $p < .05$). The means of the four trials, two on each day, combining both groups, were 4.5, 3.9, 3.5 and 3.3 respectively. As would be expected, practice effects were significant ($F = 26.67$; $df = 1,8$; $p < .01$).

Intermittent Work Period. Some practice effects continued into the intermittent work-rest period. Performance on day 2 was better than on day 1 ($F = 22.51$; $df = 1,8$; $p < .01$). Throughout this phase of the experiment, the task was presented 6 times, and subjects continued to

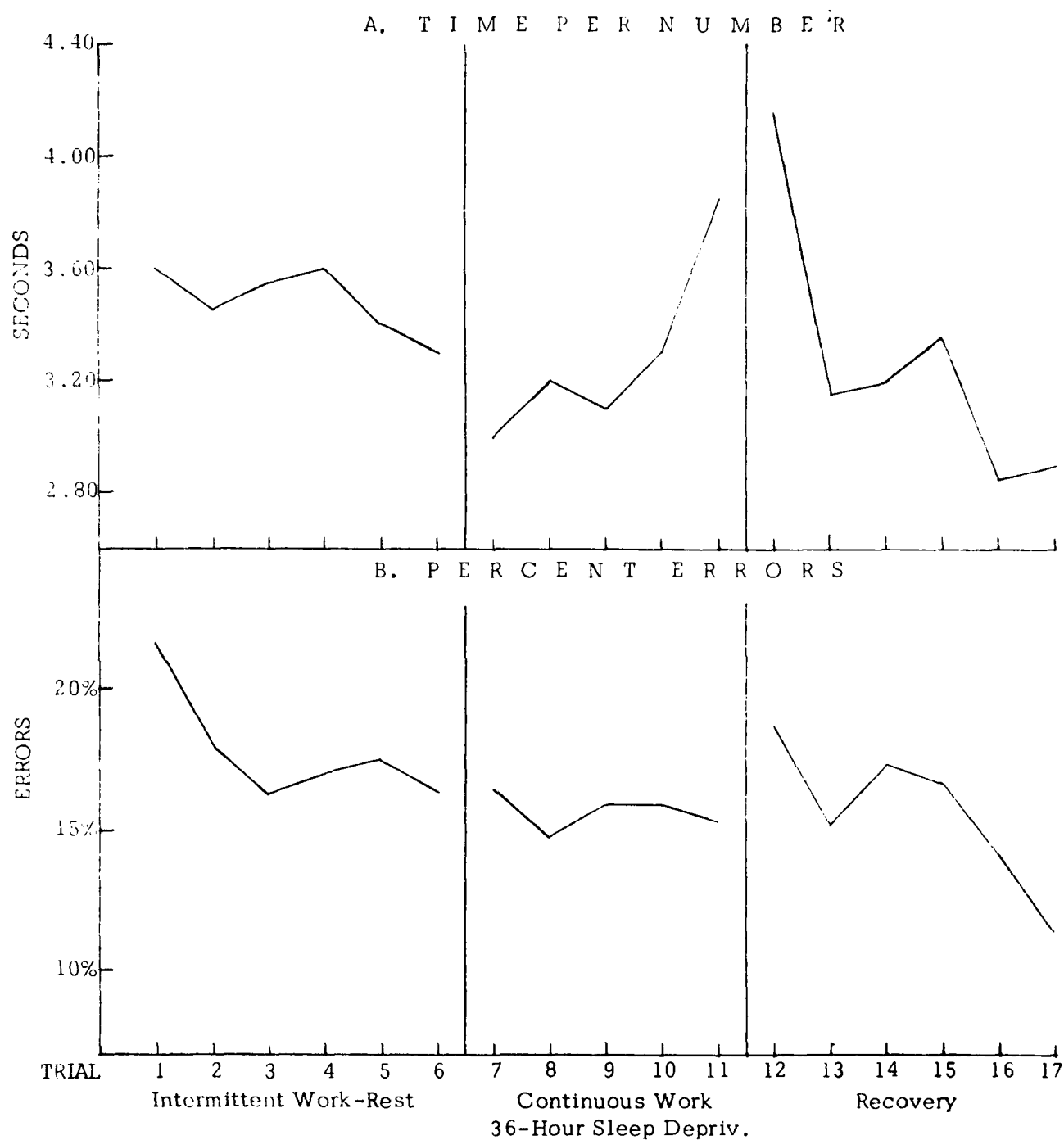


FIGURE 3

Performance on Descending Subtraction Task:

A. Time per Number B. Percent of Errors

The relationships between the trials in terms of time completed, length of previous rest, etc., are summarized in Table 15.

show steady improvement. Comparison of the initial (period 1) and final (period 6) presentations during the intermittent work-rest phase of the experiment indicated significant performance increment ($t = 2.44$; $df = 9$; $p < .05$).

Of particular interest was the effect of asking subjects to perform the task at the end of the rest period (periods 3 & 6) rather than during the normal work period (periods 2, 4, & 5). The difference between the initial rest and work periods (trials 2 & 3) ($t = 1.71$; $df = 9$; $p < .10$) indicated that the subjects may have experienced a greater degree of difficulty in responding to the task requirements during the rest period. This effect is similar to our earlier findings that awakening, particularly from delta sleep, was deleterious to task performance. However, no such effect was observed for period 6, where ostensibly the experimental conditions were similar. Unfortunately, we do not know whether, in fact, subjects were awakened to perform the task, or whether they were engaged in waking activities of their own choice.

Effects of Sleep Deprivation. The onset of the continuous work phase of the experiment was associated with a sharp improvement in mean time per number produced (for periods 6 & 7, $t = 3.07$; $df = 9$; $p < .01$). We suspect that this improvement was due to motivational effects. Subjects had been training for a considerable period, and may well have considered the deprivation phase to be the "real" experiment. From this point into the 36-hour continuous work, however, performance

on the task became worse ($F = 6.43$; $df = 4, 32$; $p < .01$). The linear trend was highly significant ($F = 8.21$; $p < .01$), but no other trends approached significance. Thus, performance worsened monotonically as sleep deprivation increased.

Effects of Recovery from Sleep Loss. After four hours of sleep, the subjects were awakened to perform the task again. As would be expected from our previous results, performance upon awakening was even worse than at the most extreme deprivation period, although the effect failed to reach statistical significance. Because no sleep data was recorded, we are unable to determine whether those subjects who showed the most decrement in performance were also those awakened from delta sleep. Between periods 12 and 13 the subjects were required to work at the performance battery and were not able to sleep; performance, however, improved markedly. Of perhaps greatest interest, however, is the dramatic reversal of performance trends, as reflected in this measure, following 4 hours of sleep. During the deprivation phase a monotonic performance decrement can be observed (see Figure 3). During periods 12 and 13, however, when subjects were also required to be alert and to work at the performance battery, performance can be seen to show a marked improvement under identical conditions. It is thus apparent that providing subjects with as little as four hours of rest after 36 hours of continuous work had important consequences for the individual's ability to perform the subtraction task. Performance continued to improve

between periods 12 and 13 ($t = 2.34$; $df = 9$; $p < .05$), and comparison of the initial measurement period (period 12) with the final period (17) resulted in a significant increment in task performance ($t = 4.04$; $df = 9$; $p < .01$). The respective mean time taken to produce each number in the series on Trials 12, 13, and 17 were 4.15, 3.15, and 2.90. By the last trial performance ability had recovered to the level observed at the beginning of the deprivation phase.

Percent Errors

For each subject and each task performance, the number of errors was scored and expressed as a percent of the number of items produced. Standard scores (mean = 50; standard deviation = 10) for each subject were computed based on all trials. Results for this measure are consistent with the speed analysis, but not as pronounced. They are summarized in Table 16 and Figure 4.

No significant changes in percent errors were found during the training period. Thus, while speed improved, accuracy remained relatively constant.

Accuracy improved during the intermittent work-rest phase of the experiment (e.g., between periods 1 and 6, $t = 2.97$; $df = 9$; $p < .01$). Most of the improvement occurred during the first two periods. Asking the subject to perform the task during a rest period did not affect error rate.

While mean time per number showed marked improvement at the beginning of the continuous work phase of the experiment, presumably

due to subjects' motivation, no such effect was observed using the percent error score ($t = .05$). Deprivation had no effect on the percentage of errors made.

Percent errors increased as a function of sudden awakening after four hours of sleep, although the effect was not significant ($t = 1.24$), and then showed a gradual improvement. The final 3 periods were significantly better than the first 3 recovery periods ($F = 11.4$; $df = 1,8$; $p < .01$). The overall recovery assessed by comparing periods 12 and 17 was highly significant ($t = 3.36$; $df = 9$; $p < .01$). Thus, while the effects of deprivation were not apparent during the deprivation phase itself, significant and meaningful improvement occurred as subjects recovered from sleep loss.

Random Number Generation

The random number generation task measures the cognitive effort that is expended while performing a simultaneous task. The greater the attentive effort required while doing another task, then the greater the deterioration in the subject's ability to generate numbers randomly. In this study a cognitive load was imposed on the subject by having him perform on a two-hand coordination task. Once this task is well over-learned, it has some of the qualities of carrying out a task "on automatic pilot," i.e., it remains relatively effortless to maintain the level of skill that has been previously acquired. Nevertheless, the degree of effort required to maintain perfect performance presumably varies as a function

of several factors, motivational and subjective, including fatigue and sleep deprivation. Thus, when the subject is extremely tired we would predict that much greater effort is required to maintain perfect performance on the motor skill, leaving less attentive energy to be allocated to the randomization task. Because there is little feedback as to how well the subject is doing on the randomization task, it is less likely that the attentive effort is primarily directed towards this task instead of towards the motor task, which gives instant feedback as to success and provides only a fraction of a second to anticipate correction maneuvers when an obvious "error" is imminent. Of course, the choice of strategy in determining which task is considered most important remains with the subject, and could vary through the experiment.

The success of this methodology is contingent upon the adequacy of the initial training and the degree of overlearning. Unfortunately, in the present study there were problems in this regard. While all subjects were able to maintain the asymptote performance much of the time, there were many trials for all subjects, particularly through the continuous work, deprivation and recovery periods, in which errors were made on the motor skill, and less than perfect performance was maintained. Thus, performance on the motor skill was not at a level required by the assumptions of the measure. In our previous work, even after fewer training trials, our subjects have been able to maintain errorless performance while generating random numbers. Although this was not so in the present study, this may have been due to an unfortunate decision to change the

procedure slightly. Rather than setting a performance criterion at a perfect trial of 120 seconds, the criterion indicating training had been established was 4 successive trials at 115 seconds on-target, or better. This was done in order to save some time during the training period, as the trials during the continuous work phase, which consisted of a minimum of 12 more combined trials on the joint tasks before the deprivation procedure, should have provided the kind of overlearning that we required. That this did not occur and that the original training criterion was not sufficiently stringent may have produced results which seemed to be considerably more variable within subjects than we have seen in our previous work.

Although the data analysis has not been completed, at least three additional factors seem to be affecting performance on the combined RNG-THC tasks. (a) The combined two-hand coordination and randomization tasks were done twice during each of the 17 trials. This was done in attempt to reduce within-subject variability, but, in fact, the first trial under all conditions almost always produced higher (poorer) randomization indices, and greater within-group variability than the immediately following second measure. We assume this is a motivational effect which we have not previously observed in work with this task (though we have not investigated it systematically). (b) There seemed to be strong circadian factors affecting the results. For unknown reasons those trials that were done at 6 a.m. by the ARLE subgroup and at 6 a.m. and 10 p.m. by the BAKER subgroup of subjects yielded poorer

ults. There are other indications of rhythmicity in the results which have not yet been fully explored. Such an analysis is complicated because the testing times during the recovery trials were displaced 2 hours from the testing times of the continuous work and deprivation trials (i.e., what was initially a 6 a.m., etc., 4-hour cycle eventually changed to an 8 a.m. cycle in terms of when subjects did these tasks).

(c) Preliminary analyses of the results suggested that independently of the 5 deprivation trials there were differences in randomization scores according to how long had elapsed since the last rest period. Trials that were conducted within a short period after the termination of a rest period were significantly better and more consistent with what we would predict from previous results than those trials conducted after longer periods had elapsed since the last recovery period. The deterioration of performance as a function of how long had elapsed since the subjects rested is intriguing and requires further systematic investigation even in this data. Of course, these subjects were working on the regular performance battery continuously throughout these periods. The poorer randomization scores and the greater within-subject variability as the subject had been continuously working for longer periods of time could be a function of fatigue, but this requires further testing.

These complicating factors made the present results difficult to evaluate. Examination of mean randomization scores for both groups over all training periods and trials, without taking into account the above factors, did not look promising. However, the above considerations

suggested to us that we should limit our analysis to a replication of the original Graham and Evans (1973) finding showing the inverse relationship between overlearning and randomization. The effect of deprivation was compared to an appropriate baseline limited to those trials which were tested immediately after the preceding rest period. There were, in fact, Trial 6 which can be considered an appropriate end to the overlearning period and in some ways the most appropriate baseline; Trial 12, which is the trial occurring immediately after the 4-hour rest period following the 36-hour continuous work; and Trial 15, in which testing is made after 2 additional rest periods of 4 and 12 hours; i.e., a total of 16 hours of rest and 12 hours of interspersed 4-hour work sessions, or 18 hours after the end of the deprivation period.

Two other minor factors should be borne in mind. We have no record of what the subjects did during the rest periods. They were given the opportunity to sleep, but may or may not have done so. It was reasonable to assume that most subjects would have slept for four hours between the end of the deprivation period, Trial 11, and the end of the next work period, Trial 12, four hours later. Secondly, even if the subjects were awakened to perform our tasks, we do not know how long intervened between awakening and the task performance. Both the subtraction and randomization performance may well be depressed if testing began within seconds or even a couple of minutes of awakening. We assume these tests were given after full arousal, and this is particularly likely to be

motor coordination and coordination-randomized task. The motor task consisted of a 1000 Hz sine wave descending subtraction problem.

Results and Discussion

The behavioral data being discussed are presented in Figure 1.

As previously outlined, only 6 trials were conducted. The data involved: (1) The initial random number performance on the combined task served as a baseline. (2) The first time the random number and motor coordination tasks were performed together (after the subject had practiced on the motor task alone for 4 trials and had typically achieved about 40 percent accuracy) indicated the extent of impaired performance due to the initial difficulty of the coordination task. (3) Trial 6 was completed during the continuous work phase, after a 4-hour rest period, but immediately before the 36-hour continuous work and sleep deprivation period began. This is the most appropriate comparison point, as all subjects had completed the combined task at this point, were within the 4 "perfect" trial criterion, and were well rested. (4) The combined task was completed after 34 hours of continuous work and total sleep deprivation (Trial 11). (5) and (6) Trial 12 and 15 were performed during the recovery period. Trial 12 occurred immediately after the 4-hour rest period that followed the 36-hour sleep deprivation. Trial 15 came immediately after 4 hours of work and 1.5 hours of rest.

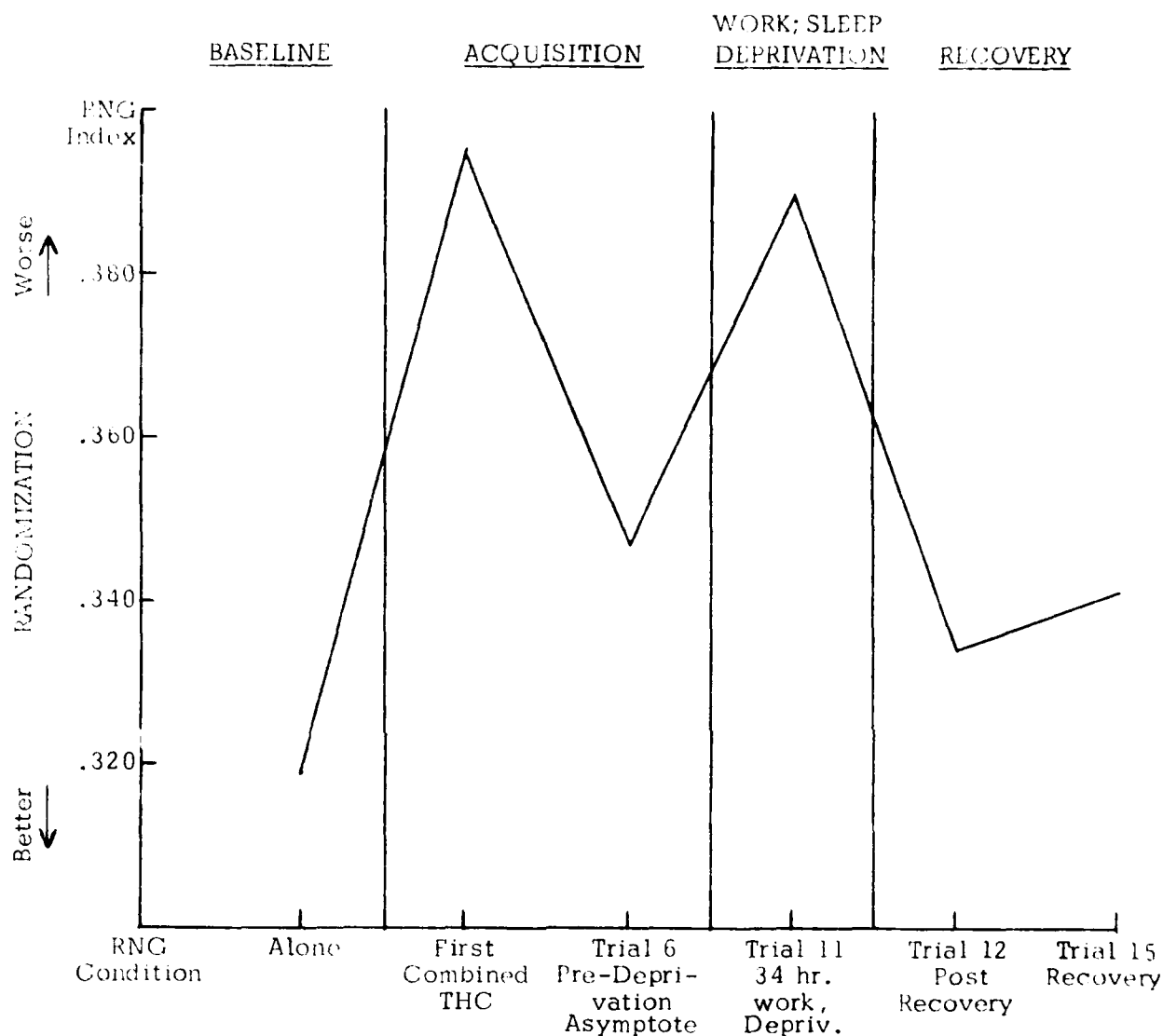


FIGURE 4

Random Number Generation: Interference during Continuous Work and Sleep Deprivation and Subsequent Recovery

Ability to generate random numbers is shown during acquisition and overlearning (Trial 6) of a motor skill (two-hand coordination), its subsequent impairment during 36-hour sleep deprivation while on a continuous performance regime (Trial 11) and its following recovery when performed shortly after 4- and 12-hour rest periods (Trials 12 and 15).

The overall analysis of variance comparing these six trials indicated significant differences occurred between at least some of the trials ($F = 3.38$; $df = 5, 10$; $p < .025$). The previous results of Ellis and Graham (1973) were replicated. The initial baseline randomization index of .319 was significantly lower than the first combined trial of .397 ($t = 2.43$; $p < .025$). (The standard deviation of the initial randomization trial alone of .065 is significantly greater than the spread of scores we have typically observed in our previous work of around .025.) This indicates the degree of performance impairment produced by the addition of the as yet unlearned motor task. At the end of the training period when the subject had met the criterion of 4 consecutive "perfect" trials while simultaneously saying random numbers (which took from 9 to 12 combined trials), the randomization index on the combined trial had recovered to .369, which is still significantly poorer than the initial baseline ($t = 2.60$; $p < .025$). It had further recovered to .347 by the end of Trial 6. Trial 6 is not significantly different from the initial baseline ($t = 1.49$; $p < .20$), but is significantly different from the disrupted randomization of the initial combined trial ($\bar{X} = .397$; $t = 1.89$; $p < .05$), indicating that randomization ability was recovering towards the baseline level as the task was becoming easier.

As predicted, the randomization index on the combined trial deteriorated markedly after 34 hours of continuous work and sleep deprivation. The mean of .389 is significantly worse than the recovered baseline in Trial 6 ($t = 2.30$; $p < .025$). This impairment in the subject

to deploy attention to an overlearned skill shows a dramatic recovery even after only 4 hours of rest. The mean randomization index after resting for 4 hours (Trial 12) recovers from .389 to .334 ($t = 2.61$; $p < .025$), but is certainly not different from either Trial 6 ($t = .72$; $p < .40$) or the initial random number baseline ($t = .77$; $p < .40$). After the next 12-hour rest period, the mean index of .342 is, as expected, still significantly less than the sleep-deprived impaired performance ($t = 3.55$; $p < .01$).¹⁵

In general, these results both replicate the original findings (during the training period) reported by Graham and Evans (1973) and tentatively indicate that this procedure might be a sensitive measure of fatigue and recovery from fatigue. A number of factors may complicate the interpretation of data derived from this task; certainly, the possible circadian effect and the increased variability after prolonged work and their possible interaction with recovery from fatigue effects require further investigation both within the present data and in future studies.

SUMMARY

While sleep has of course always been known to facilitate recovery from fatigue, there are broad individual differences in total sleep requirements; further, research has shown that sleep is not a unitary phenomenon and that different aspects of sleep may have specific functional roles. The present studies follow from the realization that little data is available about how much and what kinds of sleep are essential for its rejuvenating effects. However, some individuals can in fact utilize short periods of daytime sleep, i.e., naps, in a manner which allows them to function continuously at a high level of competence for extended periods of time. This simple observation challenges widely held assumptions about sleep needs and has major practical and theoretical implications. The studies outlined are concerned with clarifying the physiological and psychological consequences of different kinds of napping and the evaluation of some performance measures with which we have tried to assess the cognitive consequences of fatigue and recovery from fatigue.

A sample of 430 normal young adult subjects were administered an extensive sleep questionnaire designed to explore a number of sleep parameters in general as well as patterns of napping in particular. On the basis of the questionnaire responses, subjects belonging to three groups were identified: (1) Replacement nappers are individuals who utilize short periods of daytime sleep to make up for lost nighttime sleep. (2) Appetitive nappers are individuals who nap frequently regard-

less of their level of fatigue. For these the nap serves important psychological functions which lead to increased comfort and energy, apparently independent of sleep loss. (3) Confirmed non-nappers are individuals who avoid napping because, for them, it fails to be a satisfactory way of making up sleep loss. These individuals report that they generally feel worse at the termination of the nap than they felt at its beginning.

Subjects who were initially classified as typical of these three groups were then further evaluated by an extensive post-experimental interview. Only if an investigator, blind as to the questionnaire responses, categorized the subjects in the same manner as they had been classified on the basis of the questionnaire were they included in an in-depth investigation of napping patterns. Thirty-three subjects categorized in this way came to the laboratory to take a one-hour afternoon nap, allowing an evaluation of the physiological nature of their nap and an assessment of the subjective experience following it. Finally, these same subjects completed a 15-day sleep diary which permitted a detailed assessment of the relationship between daytime and nighttime sleep and provided indications about the kinds of effects these types of naps had on how they felt and performed over this period of time.

A number of significant differences in napping patterns emerged. Most striking was the tendency on the part of appetitive nappers to cycle between different stages of sleep and respond more quickly to the awakening stimulus. Whereas replacement nappers felt more satisfied if they fell asleep quickly, had more delta sleep, and felt that they had

slept deeply, the opposite was true for non-nappers. Most interesting, neither arousal variables nor physiological sleep parameters predicted sleep satisfaction for appetitive nappers. They were most satisfied with the nap if they perceived the session to be short and if they judged themselves to have been asleep for a shorter period of time than would have been indicated by their EEG.

The final portion of this report describes a collaborative study carried out in conjunction with the Performance Research Laboratory of the University of Louisville, Kentucky. This study compares the rapidly administered cognitive measures of performance that we have been using with the highly sophisticated continuous work environment as a means of assessing performance. Preliminary findings suggest that at least one of our procedures is remarkably sensitive to even relatively mild sleep loss and dramatically reflects recovery from fatigue.

The present work seems to document two major kinds of napping activity. Clearly, napping can serve different important functions for different individuals. These functions are reflected in the kind of physiological activity that characterizes the individual's nap in the kind of subjective changes that follow it. Past work has suggested that performance following the nap will similarly show differential effects. It is hoped that as napping patterns are delineated and circumstances under which naps are particularly effective are recognized, it will become possible to teach more individuals to efficiently utilize napping to facilitate recovery from fatigue.

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FOOTNOTES

¹Most questions could be quantified in one of three ways: (a) clock-time (using the 2400 hour system), or hours and minutes, in response to questions about nighttime sleeping and daytime napping parameters; (b) rating scales--usually 4- or 5-point, occasionally 10-point--in which the higher the rating the more positive, frequent, agreeable, or relevant the answer to the question; (c) yes-no answers--in which "yes" was always scored as "1" and "no" as "0"--on to questions describing subjective sleep variables.

In addition, several open-ended questions were included so that subjects could make additional comments where appropriate, although not all of these lent themselves to direct quantitative analysis.

²We are grateful to Dr. Henry Gleitman, University of Pennsylvania, for his generously allowing us to give the napping questionnaire to his class.

³All p-values throughout this report for t-tests and correlations are two-tailed.

⁴Comparisons of all 52 appetitive and 209 replacement nappers (i.e., including those 62 nappers who napped less than once a week, or who did not find napping satisfying) yielded virtually identical

differences, although several differences were not as large as when only the consistent nappers are included.

⁵This sleep questionnaire designed by O'Connell (1964) has provided the basis for elaborating some of our original hypotheses about subjective sleep satisfaction.

⁶The experimenters were Charles Graham, who conducted the introductory interview, Harvey D. Cohen, who completed the napping session and all of the associated psychophysiological procedures and relevant rating scores, and Frederick J. Evans, who carried out the post-experimental inquiry to confirm the questionnaire subgroup allocation of the subjects. The latter two procedures are described below. Each of the investigators was blind regarding the questionnaire-determined subgroup membership of each subject, and these investigators had no access to the information gathered during the other segments of the procedure by the other two researchers.

⁷For differences between the three selected subsamples to achieve similar levels of significance, compared to the original large questionnaire sample, much larger mean differences between groups on the relevant variable were necessary. However, the results reported in the previous section were, on the whole, confirmed at comparable levels of confidence.

The 12 non-nappers seemed to prefer fewer hours of sleep than the 40 nappers selected from the questionnaire ($p < .05$), but the nappers indicated they typically needed more sleep (6 hours and 13 minutes) than the non-nappers (7 hours and 21 minutes; $t = 2.59$; $p < .05$). The 40 nappers typically felt sleepy, went to bed, and fell asleep, earlier than the 12 selected non-nappers, as well as earlier than the remainder of the 169 nappers in the original questionnaire sample. The nappers typically felt sleepy at 10:52 p.m., compared to 12:54 a.m. for non-nappers ($t = 3.36$; $p < .002$). They typically went to bed at 12:22 a.m. and fell asleep at 12:35 a.m., compared to 1:09 a.m. and 1:35 a.m. for the non-nappers ($t = 2.52$; $p < .02$ and $t = 3.05$; $p < .01$; respectively). In contrast, there was less than 10 minutes difference between the replacement and appetitive nappers for each of these questions. However, the nappers did not necessarily receive any more nighttime sleep than the non-nappers, either the night before they filled out the questionnaire, or in general. They regularly slept for 7 hours and 22 minutes compared to 7 hours and 13 minutes for the 12 non-nappers. In general, these differences are relatively minor in view of the fact that reported total night sleep time is about the same for each subgroup.

These nappers showed an even greater degree of voluntary control over sleep than the 169 napper subjects in the large questionnaire sample. There were also some minor differences between appetitive and replacement nappers compared to the 12 non-

nappers. For example, among the appetitive nappers who slept in the lab there was a significant tendency for them to sleep more often on plane trips and at a play or the theater than non-nappers ($p < .05$; $p < .002$) respectively, though this was not true in the larger sample. Similarly, replacement nappers differed from the non-nappers (although they had not done so before) while reading a book ($p < .01$), while at a movie ($p < .002$), and after a good meal ($p < .05$). The tendency for the appetitive nappers to fall asleep in response to stress was much more pronounced than it had been in the larger sample ($p < .001$; $p < .05$; respectively compared with non-nappers and replacement nappers).

Thus, it would seem that the selection criteria resulted in subjects who did not differ appreciably from subjects in the large initial questionnaire sample, except for their tendency to respond somewhat more extremely on many of the important questionnaire variables.

⁸Seven subjects had to be dropped from the study either because they had radically changed their napping patterns or frequency between the completion of the questionnaire and the subject's sleeping in the laboratory (which ranged from about one week to 7 months), because the experimenter was unable to categorize the subject with confidence, or because of difficulties in scoring the EEG record.

9 Three subjects were classified as appetitive nappers by the judge but as replacement nappers on the basis of the questionnaire response. In each instance the judge indicated that there were overtones of both kinds of napping behavior in these subjects and his confidence rating was low. Most interesting was the group of 9 subjects who were categorized as appetitive nappers by the questionnaire, but who were rated as replacement nappers by the blind judge. Most of these subjects were rated with less confidence than either of the two napper groups that were included in the study ($p < .10$). Comments indicating the judge's confusion about the appropriate grouping, such as: "with strong appetitive overtones," "at first fairly sure replacement napper, but as she talked a lot, had strong appetitive overtones--almost convinced me to change but stuck to first impression" were recorded for 6 of these 9 subjects whereas such comments occurred with only 2 of the 21 napper subjects where the judge's rating agreed with the questionnaire categorization ($p < .005$). The agreement between the judge's ratings and the questionnaire categorization thus varied from very high for the non-nappers, fairly good for replacement nappers, to relatively poor for appetitive nappers. We do not believe that the results for the appetitive nappers merely reflect the low reliability of questionnaire categorization since the 9 subjects categorized correctly by the judge turned out to be very different physiologically from the other appetitive

nappers. We suspect that this group represents a special subsample of nappers, the nature of which is likely to be clarified in future work.

¹⁰These 11 appetitive and 10 replacement nappers did not, for the most part, differ from the 169 qualified nappers nominated by the questionnaire from which they were selected. Appetitive nappers typically report they nap significantly more frequently than the replacement nappers (19.3 and 12.9 times per month, respectively; $t = 2.76$; $p < .02$). Appetitive nappers were more likely to report that they could nap every day, and that they would like to be able to nap daily ($p < .05$). Although both groups were capable of controlling the onset of sleep voluntarily in several unusual circumstances, appetitive nappers were significantly more able to fall asleep during a play or movie than replacement nappers ($t = 2.65$; $p < .02$) and were more able to fall asleep in response to stress than replacement nappers ($t = 2.08$; $p < .05$). They were also able to fall asleep more readily at night ($p < .02$). Replacement nappers report that they are less likely to nap if they have had a regular previous night's sleep than appetitive nappers ($t = 3.19$; $p < .001$). Similarly, they report that the nap is significantly more satisfactory if they have received less sleep than usual on the previous night ($t = 3.04$; $p < .001$). In general, the small selected samples behaved in much the same manner as the similarly responding subjects in the larger samples, sometimes responding a little bit more so.

¹¹Hazards involved in interpreting small sample correlations are noted: while a two-tailed 10 percent significance level was taken into consideration, internal consistencies in the data were sought (though not always reported throughout).

¹²In order to test the possibility that variability rather than average patterns characterized the subgroups, the standard deviation over the 15 days for each subject on each of several variables was also used as a meaningful score characterizing the subjects' performance and sleep habit variability. In general, this variability score on each question did not produce any interesting differences between groups, and need not be discussed further.

¹³A more complex set of analyses is required to unravel the consequences of napping for habitual nappers. It is necessary to compare their responses on those nights which preceded or followed a nap compared to those responses which preceded or followed a day on which no nap occurred. Such an analysis is, of course, based on the variable number of days for each subject. For some subjects mean ratings in any one of these four categories are based on relatively few days. In the preliminary data reported (the detailed analysis has not been completed) a subject's averaged response for any of these four contingencies was excluded if there were not at least three such occasions to be averaged.

[1] We are particularly indebted to Dr. Carl A. Willis, Jr., J. J. Morahan, Jr., Bill R. Brown, and Donald L. Gorman of the Performance Research Laboratory, University of Louisville, for their collaborative help in including our two tasks in the continuing work performance battery.

[2] Elimination of three subjects whose randomization effect never recovered from the initial combined trial impairment leads to results which are much clearer but consistent with the results described.

APPENDIX

Survey of Subjective Sleep Patterns (Napping Questionnaire)	A-1
Section II (non-nappers)	A-5
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Patterns of Sleep Questionnaire Form SD: Sleep Diary ...	A-12

Survey of Subjective Sleep Patterns

Name: _____ Date: ____/____/____
 first middle last

Date of Birth: _____ Sex: _____ Class: _____

Address: _____ Phone: _____

People vary greatly in their patterns of sleep and in their preferred times for sleeping. We are interested in obtaining data on various patterns of night-time sleep and also on the frequency of ability to sleep during the daytime. We would very much appreciate your cooperation in giving us information on how you sleep, when you sleep, and how deeply you sleep, by filling in this questionnaire.

Please answer each question by checking the appropriate description of the frequency of occurrence or by filling in the blanks on the questions which have them. There is room for general comments at the end of the questionnaire. Please answer every question.

-
1. How many hours of sleep did you have last night? _____
 2. During the past year, how many hours of sleep have you regularly had? _____
 3. How many hours of sleep would you like to have each night? _____
 4. How many hours of sleep do you feel you need each night? _____
 5. Do you sleep as deeply as you would like? Yes _____ No _____
 6. When you first wake up, do you typically feel slow and lethargic? (Yes _____ No _____) or do you typically feel refreshed and ready to go? (Yes _____ No _____)
 7. Did you sleep well last night? Yes _____ No _____
 8. Do you usually sleep well? Yes _____ No _____
 9. Could you go to sleep now if you had the time? Yes _____ No _____

10. Sometimes what people do before falling asleep influences how well they sleep. Some people count sheep, others unwind by reading a science fiction novel before turning off the light. Some people like a hot drink, but this would be considered most undesirable by others. While many of us brush our teeth before retiring, others may look under the bed.

Describe briefly those activities you typically complete before falling asleep which you feel help you to sleep well. _____

11. People describe many personal preferences about the conditions under which they sleep best (e.g., some people cannot sleep with a fan blowing on them, others feel they cannot sleep unless they are close to an open window).

List as specifically as you can three special conditions which are most likely to help you sleep well:

1. _____ 2. _____ 3. _____

List three conditions you sometimes encounter under which you have a great deal of difficulty sleeping well:

1. _____ 2. _____ 3. _____

12. Indicate the appropriate times when:	Last night		Usually	
	Hour	am/pm	Hour	am/pm
a. You felt very sleepy				
b. You went to bed				
c. You fell asleep				
d. You woke up during the night				
e. You woke up in the morning				
f. You got out of bed				

INSTRUCTIONS FOR PART II

The last question you answered read:

23. Do you take catnaps during the day?

Your answer to this question was:	Always	_____
	Usually	_____
	Sometimes	_____
	Rarely	_____
	Never	_____

Like so many other things, some people nap regularly, and others never take naps, while most people fall somewhere in between--napping on occasions depending on a variety of circumstances. We are interested in studying some of the reasons why some people nap, but others do not, and what are some of the characteristics which account for whether people nap. The next part of this questionnaire is divided into two sealed sections, one colored green, on pages 5 - 7, and one colored blue, on pages 8 - 11. You should complete only one of the two sections, depending on your answer to question 23 regarding napping.

(a) IF you answered question 23 either Rarely or Never (indicating that you rarely or never take catnaps), you should turn to the green Section II on the next page (page 5), break the seal, and complete it. Do not complete the blue section beginning on page 8, and please do not break the seal on the blue section. The information you are providing, together with what you have already provided, is extremely important because it will be possible to determine whether there are differences in the patterns of sleep of those who rarely or never nap compared to those who do nap on at least some occasions.

(b) IF you answered question 23 either Always, Usually or Sometimes, indicating that you catnap at least sometimes, you should turn to the blue Section III on page 8, break the seal, and complete it. Do not complete the green section on page 5, and please do not break the seal on the green Section II (pp. 5 - 7). By answering the following questions, we will learn a great deal more about the characteristics of napping.

In summary, on the basis of your answer to question 23 about how often you nap, determine whether you should complete Section II (green) or Section III (blue). Complete the appropriate section, breaking only its seal. DO NOT break the seal of the section you do not have to complete.

A-5.

Break the seal and continue only if you answered Question 23
either "Rarely" or "Never" (indicating you tend not to take catnaps).
Otherwise, if you do catnap, turn to the blue section (page 8).

Section II

1. Listed below are several reasons why a person may rarely or never nap. Please check each reason on the five point scale: 5 indicating the reason quite definitely applies to you; 1 indicating the reason is largely irrelevant.

Definitely Applies Irrelevant

	5	4	3	2	1
a. No time available					
b. Napping is an unpleasant experience					
c. I do not have any need to nap					
d. Napping interferes with my work (studying)					
e. Napping interferes with my leisure entertainment					
f. I would not be able to fall asleep					
g. I would not feel any better after napping ...					
h. I would not feel any less tired after napping					
i. If I napped, I would not be able to sleep well at night					
j. I already get enough sleep, so do not need to nap					
k. Napping produces unpleasant physical aftereffects					
l. Napping produces unpleasant mental aftereffects					
m. Resting without falling asleep is more beneficial					
n. Napping is a sign of laziness					
o. Other reasons (specify) _____					

2. Which, in order of importance, of the above reasons, are your main reasons for not napping? 1 _____ 2 _____ 3 _____
Which of the above reasons are least important? 1 _____
2 _____ 3 _____

3. Was there a period of time when you did take naps at least sometimes?

Yes _____ No _____ When? _____

4.

a. What time of the day do you usually feel most alert and awake?

b. What time of the day do you usually feel most tired and sleepy?

c. What time of the day do you feel you work most efficiently?

d. What time of the 24 hour day would you most prefer to go to sleep?

Hr	am/pm

5. Under what ideal conditions would you be most likely to nap? _____

6. What do you think are the main differences between naps and regular sleep?

7. In what other ways do you think a person who regularly naps might differ from a person who never naps? _____

8. In our attempts to explore the characteristics of napping and nonnapping behavior, we have undoubtedly failed to mention several aspects of your own behavior and thoughts about the topic. Any other comments that you feel might be relevant would be extremely valuable to us.

Break the seal and continue only if you answered Question 23
either "Always," "Usually" or "Sometimes" (indicating you do take
catnaps on at least some occasions).

Section III

1. How often do you take naps? per month or per week

2. When did you last nap? Day _____ Time from: _____ until: _____

3. What time of the day do you prefer to nap?

4. What time of the day do you least like to nap?

5. What time of the day do you feel most tired and sleepy?

6. What time of the day do you feel most alert and awake?

7. What time of the day do you feel you work most efficiently?

Hr.	am/pm

8. How long would the ideal nap last for you?

9. What is the longest period of time you nap?

10. What is the shortest period of time you nap?

11. When napping, how long does it take to fall asleep?

12. When you do nap, how long does it typically last?

13. How long after you awaken in the morning does it take before you are ready to take a nap?

14. How long before you plan to go to bed for the night would be the minimum time you would plan not to take a nap?

Hrs.	Min.

15. Check which of the following alternatives you think you would prefer:

i. A regular (8 hours or so) continuous night's sleep

ii. Several short naps throughout the 24 hour day when you felt tired.

29. What are the conditions under which you are most likely to nap?

30. Do you sometimes feel that a nap was not very refreshing, and that perhaps you wish you had not napped? _____ If Yes, what is it about the circumstances that leads you to think so; why do you think some naps are like this? _____

31. What do you find are the main differences between regular sleep and naps? _____

32. In our attempts to explore the nature of napping, we have undoubtedly failed to mention several aspects of your own napping behavior. Any other comments that are relevant to naps that you take would be extremely valuable for us. _____

© Emily Carota Orne, 1973 Patterns of Sleep Questionnaire

Form SD: Sleep Diary

Name: _____ Day: _____
First Middle Last

Date: ____/____/____

Time of day: _____
hour a.m. or p.m.?

Instructions:

People vary greatly in their patterns of sleep and in their preferred times for sleeping. We are interested in obtaining data on various patterns of nighttime sleep and also on the frequency of the ability to sleep during the daytime. You have previously completed a questionnaire regarding your general sleep patterns and we would very much appreciate your cooperation in giving us further information regarding how you slept last night by filling in this questionnaire.

For consistency of the data it would be helpful if you could complete the diary as soon after getting up in the morning as possible. Most people find that keeping the sleep diary on a small table or chair close to the bed aids in reminding them to answer the sleep diary questions upon arising for the day.

Please answer each question by checking the appropriate description of the frequency of occurrence or by filling in the blanks on the questions which have them. There is room for general comments near the end of the questionnaire. Please answer every question.

1. How sleepy are you now?

very sleepy _____ drowsy _____ normally tired for this time of day _____
in a normal wake state _____ wide awake, too awake to sleep _____

2. Did you sleep well last night? _____

3. How deeply did you sleep last night?

very lightly; as lightly as I have ever slept. 1 2 3 4 5 6 7 8 9 10 very deeply; as deeply as I have ever slept.

-2-

4. What time did you wake up this morning? hour a.m. or p.m.?
5. What time did you get up this morning? hour a.m. or p.m.?
6. What time did you go to bed last night? hour a.m. or p.m.?
7. Approximately what time did you go to sleep? hour a.m. or p.m.?
8. About how long did it take you to fall asleep last night? hours minutes
9. a. Did you wake up during the night? ☐ yes ☐ no b. How many times? c. Roughly how long each time?
10. a. Did you get up during the night? ☐ yes ☐ no
b. How long? hours minutes
11. How many hours did you sleep last night?
12. a. Did you dream last night? ☐ yes ☐ no b. If so, do you recall the general content of any of the dreams? ☐ yes ☐ no
13. Have you taken any medications in the past 12 hours (e.g., No-Doz, Darvon, aspirin, cold pills, penicillin, Codeine, hayfever pills, etc.)?
Please list:
14. Did you perform any special or any more than usual, physical exercise yesterday--even if only for a short time? ☐ yes ☐ no If yes, please describe briefly:
Time of Day: from hour a.m. or p.m. to hour a.m. or p.m.?
15. Did you concentrate especially hard, or more than usual, on any special task yesterday? ☐ yes ☐ no If yes, please describe the task briefly:
16. a. When yesterday did you feel most tired? hour a.m. or p.m.
b. How long did the tiredness last? hours minutes
c. During morning, afternoon and evening separately, please indicate approximately what time you felt tired, and how long the tiredness lasted.
- Afternoon Evening
from to

-3-

17. At any time yesterday did you have the impression that you were "fighting off" sleep or that your eyes kept closing "against your will"? ☐ yes ☐ no

b. If yes, approximately when? _____ hour _____ a.m. or p.m.?

18. a. At any time yesterday, were you ever so tired that you had difficulty concentrating on a task which you were trying to accomplish? ☐ yes ☐ no

b. If yes, from: _____:_____ to _____:_____ a.m. or p.m.?

Please describe briefly the task: _____

19. a. Did you take any naps yesterday? _____ b. If so, how many? _____

c. How long? from _____:_____ a.m. or p.m. to _____:_____ a.m. or p.m.?

d. How did you feel when you got up? _____

e. Was the nap a good one? ☐ yes ☐ no

20. During what time period yesterday did you feel the most awake?

from: _____:_____ to _____:_____ a.m. or p.m.?

21. Approximately how many hours yesterday were you

in classes _____ hours studying _____ hours at work _____ hours

other _____ tasks or activities requiring concentration _____ hour:
please specify briefly

22. Additional comments regarding your sleep last night or about your wakefulness or drowsiness yesterday.

23. How sleepy are you right now?

wide awake; absolutely no desire to sleep or rest 1 2 3 4 5 6 7 8 9 10 the need for sleep is overwhelming; sleep is unavoidable

24. Could you go to sleep now if you had the time? ☐ yes ☐ no

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